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AN ECLECTIC ANALYSIS

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A CASE STUDY OF ACTIVITY-BASED INSTRUCTION IN A SCIENCE CLASSROOM: AN ECLECTIC ANALYSIS

By

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ABSTRACT

A CASE STUDY OF ACTIVITY-BASED INSTRUCTION
IN A SCIENCE CLASSROOM: AN ECLECTIC ANALYSIS

By

Neil Bruce Sendelbach

Many science educators have advocated the use of hands-on activities with materials and phenomena for teaching abstract science concepts and related science processes at the upper elementary and middle school levels. The major effort to implement these prescriptions has been through the development and dissemination of instructional programs. The present study was an effort to better understand activity-based teaching using existent science program materials. The goal of this effort was to provide a knowledge base for identifying and addressing the associated problems.

It has become generally accepted that understanding of classroom teaching requires going beyond the description of observable behavior to the investigation of the meanings and antecedents of that behavior. The present study viewed the teacher and students as classroom participants whose behaviors were related to their conceptual frameworks and instructional interactions. The study examined the actual events of classroom instruction. These events were then related to the teacher's intentions and the instructional program. On the basis of the three data bases, an explanatory model of the actual events of classroom instruction was developed.

The objectives of the research were to:

1) Determine the extent actual classroom instruction reflects the teacher's intentions for instruction.

2) Account for the differences between the teacher's intended approach and actual classroom instruction.

3) Attempt to account for the nature of the actual instructional activities in terms of the program materials and the teacher's intentions.

The actual classroom instruction observed reflected considerable use of the program materials and activities which involved student manipulation of materials. Almost three-fourths of the activities identified in the advocated program were included in actual instruction. Of these however, over forty percent involved some form of significant modification. A pattern of inclusion, modification or exclusion of activities from the advocated program in actual instruction related to a functional differentiation in activity types. Four activity types were identified in the advocated program primarily differentiated by the activities task and the student and teacher roles. The four types address different phases of a logical sequence for activity based instruction: 1) What activities which introduce a new idea that is going to be investigated; 2) How activities which identify the means and procedures to be used in the investigation; 3) Doing activities which are the actual implementation of the means and procedures in carrying out the investigation and 4) Why activities which attempt to develop knowledge elements specifically relating to the issue or idea presented in the what activity. In actual instruction, there was a pattern of systematic exclusion or significant modification of what and why type activities.

The overall results indicate the orientation of the teacher being related to a segmental conceptual framework. Several of the individual frames within this orientation were identified to include a "materials frame", "procedural frame", "time frame", "results frame", and "learning frame". This approach was significantly different from the holistic approach of the literal program. The teacher's dominant concern and focus of attention was associated with instructional aspects which addressed engaging the students in manipulation of materials and the associated classroom management requirements. The teacher's orientation also included a student learning frame, but, due to time constraints and the sequential process of addressing other frames first, was often not developed.

The teacher's ability to engage the students in the manipulation of materials -- doing type activities -- was very high because of the importance of the corresponding frames related to materials and procedures. Observation of student behavior during the study resulted in the generation of the hypothesis that the influence of the teacher's perspective restricted the instructional task for the students to one involving only the manipulation of the materials. The nature of instruction appears to be related to the frames the teacher has and their level of importance with respect to classroom management and student learning.

Dedicated to

my wife Ingrid and children,
who provided encouragement,
cooperation, and love throughout
all of our endeavors.

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The following study was able to be accomplished through the assistance and commitment of many different people. I would like to acknowledge the many Michigan State University faculty who contributed by providing excellent prerequisite academic and skill development: particularly Professors Susan Florio and Lee Shulman.

The conceptualization and conclusions from this study are due to the efforts of my committee. Professor Edward Smith, chairman, provided countless hours of contribution and support. Professors Susan Florio, Walter Hapkowitz and Carl Naegele also provided valuable contributions and insight. Most appreciated, however, was the ever present encouragement and motivation provided by these people.

Such a study would not be possible without the cooperation and commitment of the case teacher, Ms. W.. Her openness and belief in the worth of research founded in the classroom is appreciated. I hope the research is useful to other classroom teachers.

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CHAPTER I

PROBLEM AND QUESTIONS

The goal for science education research is ultimately to improve student learning. Improved student learning may result from an improved curriculum or improved instruction. Both the curriculum and instruction are components of the teaching-learning process. Many educators argue that efforts to improve teaching should be based upon an analysis of the complexities of the given situation, and that the basis of such efforts is a detailed knowledge of the current situation (Schwab, 1967; Stake, 1969; Florio, 1978). Without such an understanding, change is as likely to create new problems as it is to solve existing ones. This principle provides the foundation for the development of the following research problem which focuses on science education in elementary school classrooms.

The General Problem

In contrast to twenty years ago, there is currently available a considerable array of curricula for teaching science at the elementary grade level. These reflect intensive efforts by teams of scientists, educators, and psychologists and support by the federal government through the National Science Foundation. Several of these programs resulting from this effort are heavily activity oriented rather than being largely text-lecture based. This fundamental change in curriculum was the result of the science educators' and psychologists' influence concerning the cognitive processes central to school learning and their concept of science being something more than a collection of facts (Shulman and Tamir, 1977). The new programs attempt to teach aspects of the inquiry processes by which knowledge is produced as well as the specific knowledge content. Both of these changes -- teaching through activities and teaching inquiry processes -- require fundamental revision of the teaching-learning process in the classroom. Initial research efforts following the development of these programs focused on student learning. Most comparative studies have shown these new programs to be equal or superior to conventional practice regarding conceptual learning common to the modern and traditional programs which were examined (Bredderman, 1977).

In science education today much improved sets of science teaching programs and materials are available compared to twenty years ago. Current efforts emphasize building on the strengths and overcoming the weaknesses in the available science programs Several indicators provide some evidence for this shift from new program development to improvement in use of the current programs. Methods texts and courses emphasize inquiry and activity-based teaching approaches using the modern existing programs as examples. Requests for in-service workshops reflect the need for help in implementations, evaluation, and adaptation of the inquiry oriented programs. Privately developed second and third generation programs bear strong resemblance to the federally sponsored programs, while containing modifications aimed at overcoming obstacles to broader adoption and continued use.

To insure that these efforts <u>improve</u> the teaching of science, rather than simply trade one set of problems for another, knowledge of the use and effects of the existing programs or components in the classroom is required. This notion of determining the existing situation prior to proposing change is consistent with the National Science Foundation's support of Studies on Science Education Practices started in 1976. Of the four sponsored studies, the Case Studies in Science Education (C.S.S.E.) are or particular interest for their goals and research methods. These studies were designed to assess the current instructional practice for science (defined as natural science, social science, and mathematics) in the United States (L. Smith, 1978). These studies support the problematic situation of needing to identify the strengths and weaknesses of science teaching and are described in the Rationale for Analysis of Actual Classroom Instruction (p.27).

An Anecdote: Instruction in an Activity-Based Science Classroom

In order to provide a sense of the teaching-learning process and some of the problems in an activity-based science programs, an anecdote is presented. The issues of interest are the requirements of the teacher and students during the classroom period. Both the teacher and the students must be able to overcome the problems of multidimensionality and simultaneity of events during the process (Doyle, 1978). Furthermore, the teacher must deal with the factor of unpredictability. The subject matter content to be learned as an important aspect of the teaching-learning process. The anecdote, as taken from observation of classroom instruction (field notes 11-17-78), illustrates some of the many other aspects requiring attention in research attempting to understand what actually occurs when instruction utilizes an activity-based science program.

Instruction is about to begin in a sixth grade science classroom. The students have arrived from their last class, and the teacher enters the room. All the students are seated quietly at their assigned flat-topped desks. This thirty minute segment of the school day is scheduled for science and social studies. Today the teacher plans to collect a social studies assignment and then devote the entire time to a science lesson. The teacher enters the room having completed supervision of the students in the hall during class change. Class begins.

The teacher provides very detailed instructions for assembling the social studies assignment since more than one sheet of paper is involved.

> "Have it all organized and in order. First goes the one with the hemispheres; then the other one, and then the paper you wrote. Be sure to staple them together in order."

These instructions are repeated three times as students turn in the assignment. The teacher seems to be rushing the students and tells them that as soon as they are through turning in the assignment they will start their science lesson. All of this takes seven to the thirty class minutes to complete.

The teacher then provides an introduction to the day's science lesson.

> "O.K. Now, we are going to do an investigation again, trying (pause) making a gas generator (pause) umm, I will tell you a little more about it when we sit down at the science tables. So, go sit down quietly."

Both students and teacher move to their places; the students to their assigned chairs at the tables and the teacher to a demonstration table by the chalk board. As the teacher moves to this position and looks to the students, they quiet down and watch her. She begins:

> "All right, I'm going to be showing you what we're going to be setting-up, so you follow along."

Before the teacher starts the demonstration, however, she notices two students have their incomplete social studies assignments at their table. She stops and directs them to take those papers back to their desks. This interruption continues with the teacher elaborating to the whole class that when they are doing science at the tables, the only thing they should take from their desk is a pencil.

The teacher continues:

> "All right. I'm going to give you the instructions as to how you're going to do it. Then I expect you to follow.. are you ready to listen?...you can't follow very well if you are talking (two students in the class were talking together)...All right. You're going to be given one of these cups, a piece of tubing, and a couple of other items that you're going to be using."

The 'other couple of items' the students will be using in the activity are BTB solution and seltzer tablets. These two items are very significant to the subject matter content being addressed by this series of activities, the seltzer tablets in that it generates the "mystery gas" the students are to identify and the BTB solution since they have established that BTB solution can be used as an indicator for carbon dioxide gas.

The instructions continue:

> "What you're going to do, first of all is put the tubing through this (she demonstrates putting the tubing through a hole in a plastic vial's cap).

Now it's going to seem like it doesn't fit at first (as she has difficulty in putting the tube through) but just sort of squeeze it through a little and then put it (the tube) down so it's pretty close to the line on your vial; it shouldn't go below that line. The other end will go in here (shows other end of tube going to a plastic cup). This (the cup) is going to be filled one half full..about half way. the other (the vial) will be filled about a quarter of the way. This is the way it's going to be set up. Then, you're going to put this (the tubing) down into it (the cup) after you do another step. You will be given one Alka-Seltzer tablet (with this statement there is some student giggling and singing of "plop-plop, fizz-fizz") and BTB solution. I'm sure you all know what we're going to be testing for. What are we going to be testing for?"

After a very long and detailed set of instructions for how the students are to manipulate the materials for the activity, the teacher very briefly addresses some of the subject matter content addressed by the activity. From the teacher's inquiry of what they are going to be testing for, a couple of student replies are heard:

"The blue in the vial"
"Carbon dioxide"

Both student responses relate to the subject matter content of the activity but, obviously, neither one provides any sort of developed explanation of the content. The teacher continues:

"O.K. Where are we going to put this BTB?"

Student response: "In the big cup."

"In the big cup. What are we going to test for then?"

Student responses: "If the (inaudible) transferred. Blue (inaudible)."

There is a considerable amount of student talk. Some talk is still about the Alka-Seltzer and some just seems conversational.

It is hard to hear any student responses.

> "Uh, there are too many people talking. I can only hear or listen to one. Yes, Darrel?"

Darrel: " Carbon Dioxide will come from the vial."

> "O.K. To see if there is carbon dioxide in here? Yeh, right, that is what you're going to be testing for."

This brief dialog between the teacher and one student is in contrast to very lenthy and detailed attention to the way the students are to manipulate the materials for the activity. The response from Darrel is stated as one of fact with the activity being done only to confirm his idea. This is a different approach than suggested by the <u>Teacher's Guide</u> which stated that the students will determine the type of gas from the results of the yet to be done activity. The response seems to have been unanticipated by the teacher who had asked what they were going to be testing for in the activity. The teacher seems less comfortable with the subject matter content discussion than with directions for doing the activity. The teacher continues:

> "So, while one person is setting this up -- getting the tube in here (the vial top), getting the cup on -- the other person is going to put twelve drops of this (BTB concentrated solution). Think you will remember that? (the teacher wants to write twelve drops on the board, but cannot find any chalk) Twelve drops. And, this is really quick to do because you uncap this (the BTB concentrate bottle) -- Mike, would you listen -- then you are going to squeeze this carefully and count out -- don't squeeze it too hard -- you're going to get drops out of there -- if you squeeze it too hard it's going to squirt out and you will have a mess on it and possibly stain your clothes. So, I put two drops in there, but you will count up to twelve."

There is a good deal of student talking and movement now as the students obtain the designated materials. The teacher has completed distributing the cups and looks at the <u>Teacher's Guide</u>. She then continues:

> "All right. I will give you a cup of water. I'll just bring it to the tables and you can pour it into both of those (the cup and vial) for yourselves."

As the teacher moves from the first group to the second she must realize the one cup of water she is providing is not sufficient since she says in a quiet voice as if talking to herself:

> "I think we will be a little short, won't we... Put that (the water just being distributed) in your vial for now."

She continues to circulate around to other tables to provide water to each. During this time a student asks how much water to add to the vial. The teacher only responds that those instructions have already been given. She circulates around the room again to supply the students with additional water. The students continue to assemble their generators. A student asks of they can add the BTB. The teacher responds to the whole class that they can add the BTB. The students are very careful to add only twelve drops.

Most pairs of students have assembled their generators and have added the BTB solution. The teacher is standing at the front, by the demonstration tables, and continues:

> "All right. I want your attention. (There continues to be some student talking and fidgeting as they continue with the activity.) Now, if you have

> gotten your BTB solution in, ah, I notice most of you have your hose in the BTB solution. I want you to take it out of the BTB now, because after you put the Alka, ah, the seltzer tablet... (pause, still some student talking and commotion with their materials)... Are you all ready to listen ... (pause) You won't know how to do it unless you listen."

The students are busy with the materials and are therefore more difficult to get to listen. In addition, the teacher seems sensitive to the previous student reaction when she said Alka-Seltzer. There was a shift this time to saying only "seltzer tablet". With this there was no interrupting student response. The students are now paying attention to the teacher and she continues:

> "After you -- you're going to have to open this (the vial) of course -- leave your hose in that (the cap) but open this (the vial). Drop the seltzer tablet in there, see that is gets started, then put the cover on. Do not have the hose in this cup right away until it gets going. Then when it gets going, after that, you think that it has bubbled enough ... (inaudible)... carbon dioxide."

The procedures the teacher describes represent a fundamental modification from the procedures described in the <u>Teacher's Guide</u>. The changes are subtle but significant. A tremendous burden is placed on the teacher to provide all the instructions for assembling the materials since there is nothing in the <u>Student Manual</u> for this activity. The <u>Teacher's Guide</u> suggests the teacher set up a sample generator substituting water for BTB solution in the cup. Then the <u>Teacher's Guide</u> suggests the the teacher actually drop a seltzer tablet into the vial and develop through student observations that 1) the tablet dissolves,

2) the tablet produces bubbles as it dissolves, and 3) the gas bubbles through the water in the cup. The teacher is then to ask how they might determine if the gas contains carbon dioxide. Instead of this procedure, the teacher starts by providing instructions for assembling the generator; tells the students they will be using Alka Seltzer tablets; assumes they know the tablets bubble; and asks if they know what they will be testing for in the activity. The changes are significant since it leaves much of the subject matter content to be learned somewhat vague -- some students may understand but others may not. There is a fundamental shift by the teacher from the purpose of the activity being one of reinforcing the students' understanding of the use of BTB as an indicator for carbon dioxide to one of correctly following instructions in assembling the gas generator.

The teacher continues:

> "This (the tube) should not be down to the bottom (of the vial) -- remember that. As I looked around everyone had it (the generator) done quite well. O.K. There will be one of these (seltzer tablets) for each of you."

The teacher then circulates around the room and distributes the seltzer tablets. The students add the tablets and get excited about the fizzing and bubbling. There is a considerable amount of student talking.

Twenty minutes of class time have elapsed; there are ten minutes before the next class arrives. The teacher circulates around the room and watches the students' activities. The students see the color change in their BTB solutions and talk to each other about the different colors. There is still considerable talking about the Alka-Seltzer -- "plop-plop, fizz, fizz."

Some of the students start shaking the vial with the seltzer tablet. This results in some of the liquid from the vial going through the tube and into the BTB solution, causing some color changes in the BTB solution. As other students see this, they too shake the vial and get color changes. The teacher moves to the front of the room and begins to speak.

> "O.K. If you've had yours work-- your solution has turned yellow -- you know there is the presence of what?"

In general, the students are listening to the teacher, but they continue to handle the materials too. Many students respond outloud with "carbon dioxide". One student says "CO_2". The teacher continues:

> "O.K. Now, you've had a chance to set this up, now each two people are going to have to get this equipment put away. The vials should be rinsed off very thoroughly as well as the hose -- or tubing, so that all that stuff is out of there. I'm going to ask that Table 1 begin by pouring out the stuff now and rinsing it out thoroughly and putting it there (by the sink) to dry. Use both sinks. (one of each of the two pairs at the two different sinks).

With these instructions, the two pairs of students at Table 1 move to the sinks and begin cleaning their materials. The teacher observes their progress from the front of the room while organizing materials at the demonstration table. Two students at the table next to her comment about the color changes they got (green and orange) from shaking the vial. The teacher does not respond to them although indicates through eye contact she heard their comment. She continues to supervise cleanup and call the next table when students are done. As the students finish their cleanup, they return to their desk seats. While the last two students are completing cleanup the teacher notices it is 1:30. She tells the students that have not handed in their social studies assignment to get them finished as quickly as possible. She then dismisses the class.

This anecdote illustrated a number of features of an activity-based science program as well as factors which influence instruction when it is used. The program is activity-based -- much of the learning is intended to grow out of direct student involvement with materials and phenomena. As illustrated above, this opens the possiblity for addressing a variety of learning outcomes, varying from factual information -- such as the properties of BTB -- to more involved procedural knowledge applications -- such as forming a hypothesis and designing an experiment. It also illustrated how addressing these outcomes for individual children or the entire class is subject to influence from a variety of forces. Furthermore, the anecdote illustrated the complex nature of an activity-based science classroom as a system; a functioning social system. The number of options available to both the teacher and students increases in such a classroom setting. The teacher's influence and significance is reflected in the choice of activities, the directions employed, the discussion initiated, and many other ways. Yet, the classroom system itself has an influence on instruction that at times is not only operating without the direct influence of the teacher, but without apparent awareness of the teacher and students as well.

It is this interplay of forces which must be analyzed to understand the use being made of a given activity-based science program in order to derive implications for the improvement of science instruction. Prior to further science efforts of teacher pre-service or in-service training we must better understand what in fact actually occurs and why such events occur in the classroom when instruction in activity-based.

Overview of Problem and Approach

This study investigates the teaching-learning process in an activity-based science program. The subject matter being addressed is important, common to the elementary and middle school science curricula, and exemplifies the common practice of using activity-based instruction to teach abstract concepts. As a basis for further attempts at improving instruction of such topics, we must first understand what is currently being done. To do this requires understanding what is actually occurring in the classrooms where instruction is addressing an abstract topic.

The diagram in Figure 1 identifies the focal points for analysis. The literal program approach is the approach presented in the program materials, interpreted as precisely as possible.

An interpretation and modifications of this approach are reflected in the teacher's intended approach for using the materials. The actual classroom instruction reflects the interplay between the program materials, the teacher's intentions, the dynamics of the classroom system, and the individual students.

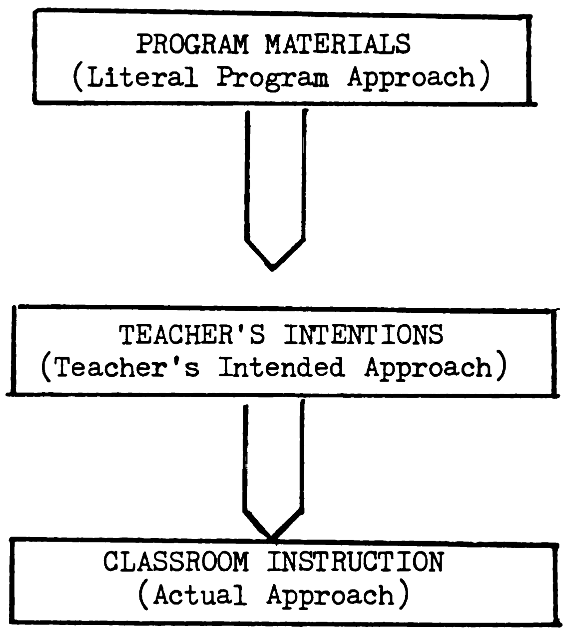


Figure 1 - Focal Points for Analysis of Program Use

One of the factors influencing the teacher's intentions for instruction and the classroom activity is the curriculum program. To understand the nature of this influence, the information provided in the literal program must be determined. The procedures for analyzing the literal program focus on the activities as the unit of analysis, and activity features (e.g., task, teacher and student roles) as components of the analysis.

The teacher is a significant factor in both establishing the classroom environment and in determining instructional content. The teacher's intentions for teaching the instructional program must, therefore, be determined. In order to investigate the teacher's intentions, the Science Teacher Planning Simulation System (described in detail, p. 50) previously developed in recent research (Smith and Sendelbach, 1977) was utilized.

The examination of what actually occurs in instruction was the key point of this investigation. This was done using a holistic approach -- both in the investigations' design and procedures -- in order both to describe and account for the teaching-learning process.

All three components of the study were necessary and inter-related. Stake (1974), warns against only considering the congruence between program developer's intended outcomes (objectives) and the observed outcomes. He advocates additional investigation into the antecedents to the observed instructional transactions. The literal program and the teacher's intentions are influential antecedents to the actual classroom instruction and therefore needed to be included in analysis of the actual classroom activities.

The necessity for considering both the literal program and the teacher's intentions is also consistant with an information processing theory (Newell and Simon, 1972) and notions of ecological psychology and ethnography from previous studies of the classroom (Doyle, 1977; Yinger, 1978; Florio, 1978). These perspectives relate to a view of the teacher as a decision maker and problem solver. The perspectives are common in considering two important and necessary components in the problem solving process: the curriculum program and the classroom enviornment. Since decision making and problem solving require thinking, the influence of these components on thinking, decision making and problem solving, need to be investigated.

Research Questions

In general terms, the research questions of this study were:

A) What is the nature of an activity-based science classroom?;

B) How representative of this teacher's intended instruction is actual instruction?; and

C) How are the teacher's intentions for instruction related to the literal program approach?.

These questions are elaborated below in the order in which they will be addressed.

1.0 What are the activities in "Part Three", the "Oxygen-Carbon Dioxide Cycle" in the SCIS program and what features are identified?

2.0 What are a teacher's intentions for instruction of the Oxygen-Carbon Dioxide Cycle?

  2.1 How is the program approach reflected in the teacher's intended approach?

2.2 What are the nature of the teacher's modifications of the program approach?

2.3 What accounts for the differences between the program approach and the teacher's intended approach?

3.0 What is the nature of classroom instruction for the "Oxygen-Carbon Dioxide Cycle"?

3.1 What actually occurs in the teaching-learning process in the classroom during the activity-based instruction of the "Oxygen-Carbon Dioxide Cycle" and how can these occurrences be accounted for?

3.2 How does the actual classroom instruction reflect the teacher's intended approach and the literal program approach?

3.3 What accounts for the differences between the teacher's intended approach and actual classroom instruction?

The Selection of Program Sequence

The above rational and research design could be used to justify careful examination of any portion of any program for which evidence of relative use and instructional success has been documented. However, high priority should be given to the selection of portions of programs dealing with topics of special importance; topics where either learning problems have been encountered or topics especially important to the science curriculum.

The learning of a concept like ecosystem is widely addressed by curricula at the middle school level. Ecosystem is not only a central concept in biology, but is becoming more and more important as a model for dealing with complex environmental problems. Fundamentally, the concept of an ecosystem involves the organism - environment relationship; the interrelations between plants, animals, sun, air, water and soil.

Because of the relatively wide use of the Science Curriculum Improvement Study program (SCIS) and previous research efforts with the sixth grade level, the use of the SCIS Ecosystem unit was selected as the topic of the present study. The instructional strategy in the SCIS program is almost exclusively activity based and is typical in nature of other existing science programs attempting to teach complex concepts. Basically, the students are provided with activities designed to present some notion of an overlying concept or "conceptual scheme" -- ecosystem -- and then provided with activities designed to address the component concepts -- water cycle, oxygen-carbon dioxide cycle, etc.. Whether students or teachers are successful with this strategy for learning and teaching complex scientific concepts is an important question. Pilot research indicates that teachers frequently modify this approach (Smith and Sendelbach, 1977), and teach each of the component concepts independently without relating them to the major overlying concept (Sendelbach, 1978).

For this study, the specific focus was "Part Three" of the SCIS Ecosystem Unit, a five week sequence dealing with the "Oxygen-Carbon Dioxide Cycle". This sequence is representative of a "middle level" topic in the Ecosystem unit. The unit can be taught as a distinct conceptual entity in isolation, (the concept of plants producing oxygen and carbon dioxide, and animals producing only carbon dioxide), it can be related to the ecosystem concept (the cycling of oxygen and carbon dioxide in the ecosystem), or it can be taught by emphasizing the specific factual information developed in the activities (BTB is an indicator for carbon dioxide, a seltzer tablet produces carbon dioxide, etc.).

Furthermore, "Part Three" involves a complete sequence of the SCIS "Learning cycle" (Ecosystems, Teacher's Guide, 1971, p. 16). The phases of the cycle are characterized by fundamentally different types of activities and are referred to as exploration, invention, and discovery, respectively.

The exploration phase is characterized by allowing the students to spontaneously handle and experiment with materials to see what happens. Exploration type activities involve very minimal guidance in the form of instruction or specific questions by the teacher. Exploration type activities are most frequently involved at the beginning of the cycle.

The next phase involves invention activities. Invention activities are much more teacher centered. These activities are designed for the teacher to provide students definitions and phrases for new concepts. The concepts presented are intended to provide the students a framework for interpreting the observations made from exploration type activities.

The last phase of the cycle is discovery. Discovery activities are characterized by providing opportunities for students to find new applications for concepts developed from invention activities. Discovery activities reinforce previously learned concepts and enlarge and refine their meanings.

The activities in "Part Three" involve all three types of activities and represent a complete learning cycle. In addition, since "Part Three" is the third cycle through the cycle in the Ecosystem unit, one is more likely to observe characteristic treatment of the learning cycle as compared to observation of the first cycle. A better understanding of the nature of classroom dynamics when instruction is activity based and of the forces resulting in particular instruction practices for different students will provide valuable information for further curriculum and teacher development.

Implications

This study has implications for the classroom teacher, teacher education and curriculum development. One of the seemingly perpetual issues nagging education, including science education, is the relationship between pre-service teacher training, research, current instructional practice, and curriculum improvement. Each of these interests have a common base -- to improve instruction. A case study identifying what actually occurs within a classroom based on activities for instruction and some level of explanation of the relationship between the participants provides information important to the issue of activity-based science programs as an approach to improving instruction.

The analysis of the literal program provides information about existing gaps or ambiguities in the program for dissemination to current and future program users. For pre-service teachers, the analysis provides information about activity features to consider in examining a developed program as an organizational framework. More directly information is provided for curriculum improvement.

The analysis of the teacher's intended instructional approach has implications for curriculum modification and pre-service instruction. The curriculum is one of the major influences on the teacher in planning for instruction. Understanding the teacher's interpretation of the curriculum and reasons for modification, provides direction for curriculum improvement.

The primary thrust of the study relates to the actual classroom as a system operating with activity-based instruction. Since activity-based instruction is advocated by many educators and is the basis for many science programs, the finding of what actually occurs and some level of accounting for these occurrances has implications for curriculum modification, preservice training, and in-service training.

Given the information derived from this study, a preliminary step to instructional improvement will be satisfied. This study will provide information of a given current situation. For classrooms of a similar nature, implications for change can be developed with a clearer understanding of the difficulties. Changes based on an understanding of the existing situation are more likely to solve identified difficulties than create new problems.

CHAPTER II

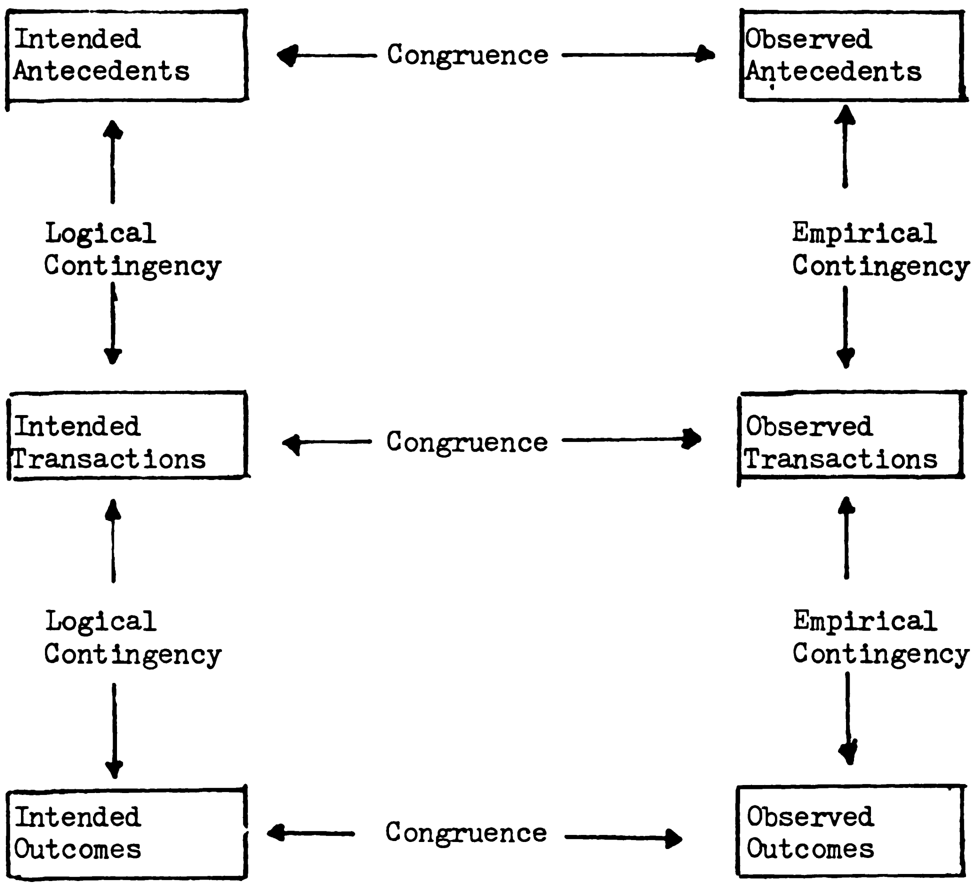
RELATED RESEARCH AND THEORETICAL BACKGROUND

The reported research is a case study of activity-based instruction for an abstract science concept. To develop a more comprehensive understanding of this phenomenon, the study focuses on three interrelated aspects of the teaching-learning environment: 1) the program approach as reflected in the program materials, 2) the teacher's intended approach as reflected in the teacher's plans, and 3) the actual classroom instruction.

This theoretical framework is an elaboration of part of a research model proposed by Stake (1974). This model is shown in Figure 2-1. The model is composed of six components; three components in the Intended column and three in the Actual column. Between the column components, Stake suggests research investigate the question of contingency. The question of contingency asks whether there are features in any of the components dependent on features of other components, and if so, whether the requirements are fulfilled or met. The difference between logical contingencies and empirical contingencies relates to the one column representing intended or theoretical conditions and events while the other represents actual conditions and events. Logical contingencies are based on events and conditions

Figure 2-1

A Representation of the Processing
of Descriptive Data *



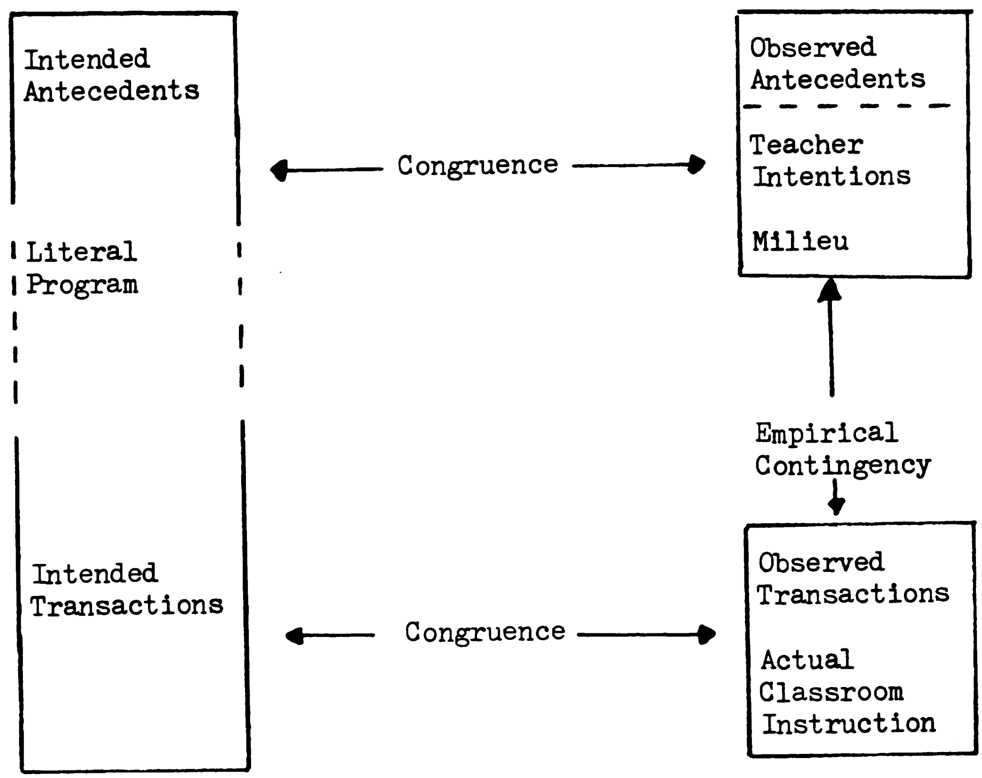
* Source: Robert E. Stake, "Language, Rationality, and Assessment", in Curriculum Evaluation, David Poyne, Editor, 1974.

intended to occur or be present which are theoretically deduced or related. Empirical contingencies, on the other hand are events and conditions actually occurring and which are related. Between the columns, Stake recommends investigating the congruence between what is suggested (intended) and what actually occurs.

This study focused on the Antecedent and Transaction components of the Stake model. The intended and observed Outcome components are beyond the scope of this study. The representation of the Stake model for this study is shown in Figure 2-2. The analysis of the SCIS literal program approach represents both the intended antecedents and intended transactions components from the model. The logical contingency question between these two components is assumed since the analysis is based on the actual program materials. This acceptance means that the intended conditions and characteristics the SCIS program developers theoretically intended to be present in both sixth grade students, teachers and classrooms are in fact related to the activities and instruction materials the literal program represents. Furthermore, since the contingency arrow is bi-directional between the antecedent and transaction components, the activities and instruction represented in the literal program must be consistent and representative of the factors and ideas which were the intended antecedents of the program developers. Such antecendents may include such items as a public school education philosophy, student learning theory, and teacher capabilities. Whether in fact there is a logical contingency

Figure 2-2

Elaboration of the Components in
the Stake Model of Interest



between the intended antecedents and intended transactions can only be answered by the program developers since they know all the intended antecedents.

The contingency between the other two components of the model, however, can be investigated. The observed antecedents are investigated by analysis of the teacher's intentions and the instructional milieu. The observed transactions component consists of an analysis of actual classroom instruction. The questions of congruence with the analyzed intended antecedents and transactions and the contingencies between the teacher's intentions and actual classroom instruction are addressed in the analysis of each component.

Since student learning is primarily derived from instruction, this study is a prerequisite to analysis of student learning outcomes. The completion of this study provides the background for later investigation into student learning.

This section presents relevant research, theoretical background and rationale for the approach to each of the components of this study. As the major focus, the analysis of classroom instruction is discussed first followed by sections dealing with the analysis of the literal program and teacher plans, respectively.

Rationale for Analysis of Actual Classroom Instruction

The classroom environment in any teaching-learning process is complex. Doyle (1977) defines factors related to this complexity as: 1) multidimensionality, 2) simultaneity, and 3) unpredictability. Teaching subject matter content in such an environment is a very difficult task. By making the instructional mode activity-based, the classroom complexity, as defined, multiplies (as illustrated in the anecdote). More directing procedures are required, and leaps from observations to conceptualizations are required. If the activity is done individually or in groups, in contrast to a whole class working simultaneously, the complexity increases again. Each student or group must interpret instructions, each must obtain appropriate equipment, and each must attend to learning while in a more dynamic social setting. These are some of the requirements and complexities of activity-based science program classrooms.

Past science education research has investigated various features of the teaching-learning process in classrooms. Studies have individually focused on such features as the frequency of higher- and lower- cognitive questions, rate of positive verbal praise, number and nature of teaching criticisms, number of probes, frequency of explaining links, sequencing of activities, etc., in activity based classrooms. These studies were done to determine the nature of the classroom with respect to one of the particular features and to determine if there was a correlation between student achievement and the classroom feature (Berliner, 1976). Such features have also been used in determining whether the teaching approach advocated by activity-based programs was, in fact, being implemented (Moon, 1971). These specific behavior oriented studies have also shown a positive correlation between use of the program and frequency or degree of use of the advocated feature. Repeated studies or studies involving numbers of teachers, however, are inconsistent with respect to the relation between these features and student achievement -- one of the main indicators of "success" of instruction. For example, increasing the frequency of high-cognitive questions by the teacher did not always increase student achievement. Berliner concludes that "frequency counts are very useful information, but we now feel that the qualitative dimension, dealing with judgments about the appropriate use of skills, must enter into our observations of teaching " (1976, p. 372).

Other research studies attempt to account for some of the qualitative nature of the classroom. Such studies introduce notions like the 'business-like' nature of the classroom, 'clarity' of instructions and 'with-it-ness' of the teacher (Rosenshine, 1971; Ryans, 1960; Kounin, 1970). These features more consistently correlate with successful instruction than the previous features, and therefore, indicate a more direct connection with successful instruction. The findings, however, offer no explanation of the processes involved in obtaining the desired classroom qualities. Partly for this reason, the results do not provide a means for getting back to either the actual behaviors or the context out of which the interpretation was made. They leave open questions such as "What do you mean by business-like" and "How can I make my classroom more business-like?".

The classroom variable recently receiving the most attention is teaching and learning time (Bloom, 1974; Harnischfeger and Wiley, 1976). Research on the relationships between instructional time and learning has produced striking results (Harris and Yinger, 1978). Studies of the average instructional time in the school year (Wiley and Harnischfeger, 1974) and of time allocated to different subject areas (Fisher, 1976a, 1976b; Harnischfeger and Wiley, 1977) have found large variations in instructional time and strong relations between instructional time and achievement. This work has direct implications for policy making at several levels. Such issues as length of the school day and of the number of days in the school year are potentially affected by this relationship. More relevant for curriculum building, is the effect of time with respect to specific learning tasks. However, the effects reported so far "are at present merely suggestive" (Harris and Yinger, 1977). Harischfeger and Wiley (1976) are aware of the complexity in the teaching-learning process, but have chosen to ignore ecological variables in the classroom and only measure time students are engaged in various activities as a discrete variable. Their position is stated: "We feel that the primary characterization of settings should not be so complex, because the reality is, in fact, simpler... Later, as empirical evidence and practical experience grow and as conceptions become clearer, we will have to find an explicit role for the subsetting "(Harnischfeger and Wiley, 1976, p. 20).

Thus, there still remains a lack of explanation of the differences in engaged time. The implication of such work for classroom instruction is the obvious goal of shortening time spent off-task in order to increase on-task time. But how this is achieved by teachers remains a mystery.

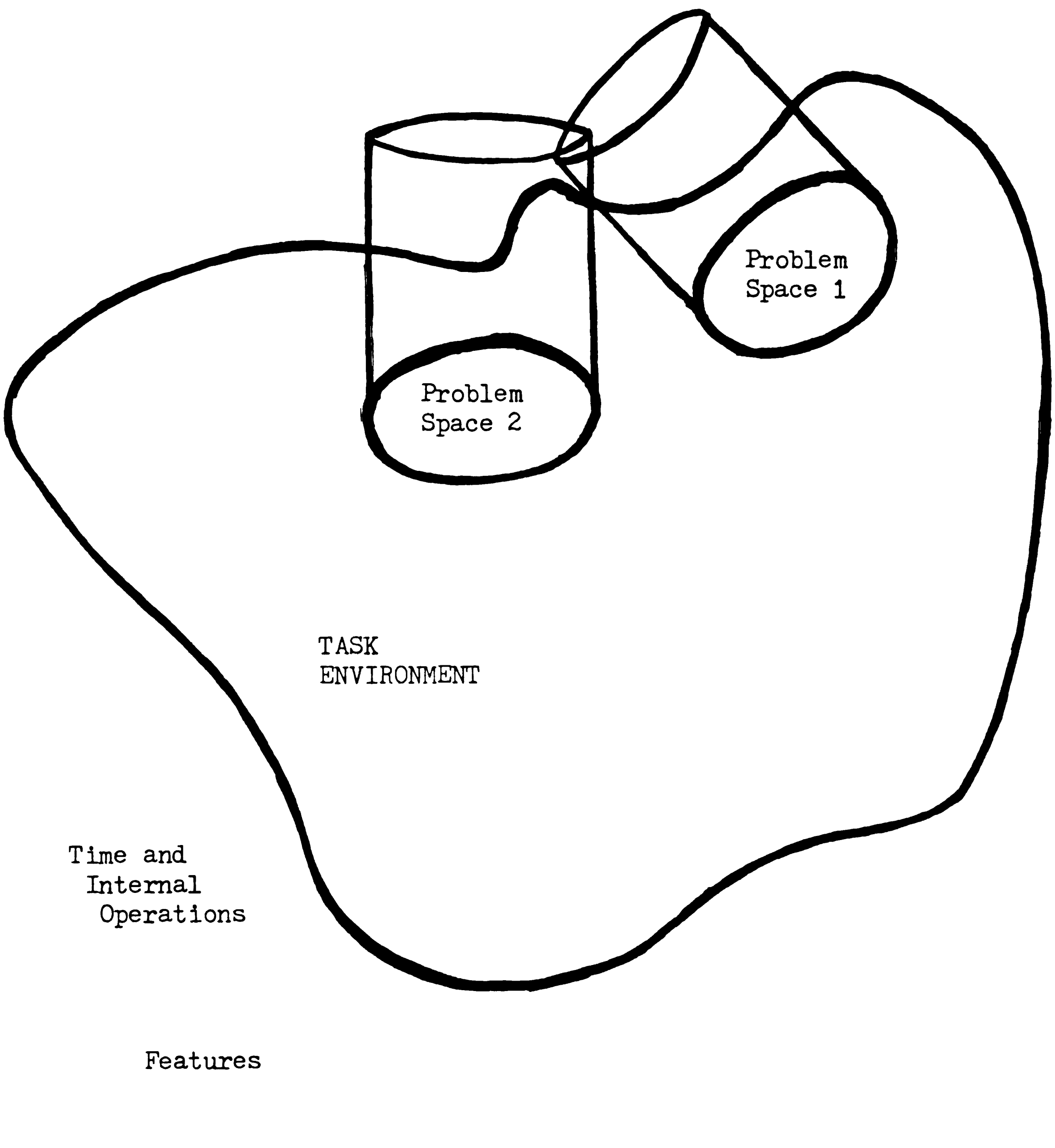
The perception, transformation, and representation of stimuli from the task environment by an individual is defined as the problem space (for that individual). For a given task environment, therefore, there may be as many unique problem spaces as there are individuals. Newell and Simon describe the process of development of a problem space as follows:

> "He (the problem solver) must uncode these problem components - defining goals, rules, and other aspects of the situation - in some kind of space that represents the initial situation (task environment) presented to him, the desired goal situation, various intermediate states, imagined or experienced as well as any concept he used to describe these situations to himself." (p. 59)

This definition allows all sorts of unique encodings of a task environment into problem spaces. Figure 2-3 illustrates the relationship between task environment and problem space. An individual in a task environment may develop multiple problem spaces over an extended period of time and different individuals may form different problem spaces from the same task environment. No particualr description or multiple descriptions of a task environment are able to claim either complete or exclusive veridicality.

Figure 2-3

Relationship Between Task
Environment and Problem Space



This ecological psychology perspective is consistent with the results of problem solving investigations to date. Simply, ecological psychology expands the considerations in the study of thinking and behavior of an individual explicitly to include the environmental influences and requirements. This is the information processing notion of the individual forming a problem space within a task environment. The important idea from these two perspectives is understanding that problem solving and decision making by an individual requires attention to both the problem solver (the "psychological" and "processor" components) and the environment (the "ecology" and information components).

To investigate the actual classroom instruction, therefore, a holistic and multi-faceted approach is necessary. Since the primary goal is to understand what actually occurs within an activity-based science classroom, the most appropriate technique for investigating these events and accounting for them is an ethnographic perspective -- field work, interviews, etc.. By observing the participants engaged in the classroom process, the salient features of their activity will be able to be seen in the context of other classroom activity features. The emphasis in ethnographic investigations of the classroom instruction is on description and fashioning hypotheses to account for recurring patterns of participant behavior, rather than on testing fixed a priori hypotheses, predictions, and generalizations (Doyle, 1977). The findings from such an investigation will then be grounded in actual setting and will be able to communicate implications to others in similar settings.

Concepts and significant features from previous research often provide some initial framework for structuring the initial questions, descriptions, and explanations. Additional concepts are created as further events are observed and analyzed which cannot be described with available frameworks. Thus ethnographic procedures do not restrict the description and analysis to predetermined features or described catagories. This is a fundamental change from the quantitative behavioristic approach discussed previously. Florio (1978), summarized the observational task:

> "Good field workers know that observation, no matter how carefully conducted and noted, is impoverished as a descriptive or analytical method if it reflects solely the researcher's interpretations or categories for what is seen or heard. Adequate field work must also uncover the categories -- or way of cutting up knowledge about the world -- or participants. In this regard, participants cannot always tell us all they know in their dealings with one another." (pp. 21-22)

Past and recent research following such a holistic approach has provided significant insight into the teaching-learning process, and has been relevant to both research and practice. One of the earliest of such studies was by Jackson (1968). The work's relevance and communicative traits are evidenced by the popularity of the resulting book, Life in Classrooms. The features of school life, such as lack of individual identity, crowding, and waiting identified in this study have some relation to school life in many schools not included in the study, and are shown to be related to other features in the school setting.

The CSSE studies previously mentioned used an ethnographic perspective to determine what the state of science education is in selected school districts. Specifically, the major purpose was reported to be a description of the status of pre-college science education in the United States in the 1976-77 school year. The project set out to investigate:

1. How is science being taught today?
2. What are the current conceptualizations of science in the classroom?
3. What are the current encroachments upon the science curriculum?

While the researchers assigned to each of the ten case studies were familiar with the suggested potential issues to be addressed, the reported analysis was dependent upon the issues found to be relevant to each case. So while each of the reports is a description of the behavior of science education in its habitat, each case is unique and "subjective" in that each researcher decided which issues were relevant to the needs of the funding agency, the National Science Foundation. The implications and final conclusions have not yet been determined from the project, but the director claims to have identified issues of teaching and learning for science education. Each case provides information about what is actually happening in science instruction for a school district and an analysis of the interacting forces from which the actual instruction results. Since the results reported for each case are accounted for in the analysis, changing the teaching-learning process by changing funding can be attempted with a knowledgeable framework. The prerequisite of adequate knowledge of the existing situation is known to reduce the probability of only trading problems. As argued above, features found important in other studies are useful in guiding observations. Similarly, features of the other two components of this study -- the program approach and the teacher's intended approach -- helped guide observation of actual classroom instruction.

This study investigated the teaching-learning process in a classroom using an activity-based science program. The previous paragraphs have argued for this investigation to be in a holistic perspective including the use of ethnographic techniques. This methodology was used to analyze the actual classroom instruction section of the study. The main goal of the study, to understand what occurs in the classroom based on activity-based instruction, requires such a holistic perspective. The background provided by the analysis of the literal program approach and the analysis of the teacher's intentions extends the researcher's perspective.

The actual classroom instruction of interest has a foundation in a specific "program approach" in contrast to an instructional program developed or organized by the teacher from a potpouri of sources. Another goal of the study was to derive knowledge of the influence of such a developed instructional program on instruction. An ethnographic analysis of actual instruction would provide information about such instruction, but would not provide information about the approach suggested by the program. Such information was needed to determine how the actual classroom approach relates to the program approach. Further information concerning the teacher's intentions was required in order to account for the modification from the program approach to the actual classroom approach. These two problems are addressed respectively in sections "Rationale for Analysis of the Literal Program" and "Analysis of Teacher Intentions".

Rationale for the Analysis of the Program Approach

Regardless of the type of program involved, science teaching in the public schools is largely program based. That is, programs or components of programs provide a point of departure for the teacher's planning for and carrying out of instruction. The classroom instruction which occurs through the use of the program or some program component reflects the selection, modification and interpretation of the program by the teacher. Instruction and program use are also effected by the active influence of the students and the classroom interactions.
The program is one component of the teacher's task environment. While analyses could be made of different teacher's intentions for use of the program and their differences compared, a stable comparitive base of what instruction would be like as described in the program materials seems more useful. To understand and derive implications from the teacher's interpretation of the program and of the uses being made of a program, detailed knowledge of the program as literally represented in the program

materials is required. Without such knowledge, distinguishing teacher innovations or other forms of modification from the use of the program as it is literally represented would be impossible. Furthermore, to be rigorous and to provide a stable base for extended lines of inquiry, detailed representations of the program's approach need to be made explicit.

Presently available characterizations of programs are largely the idiosyncratic descriptions each developer prepared to accompany the program. They are usually in the form of some combination of scope and sequence charts, lists of objectives, and narrative rationales. While these are useful in communicating certain aspects, they are inadequate representations for research purposes. They are incomplete, not expressed in a common, generally understandable mode, and not necessarily an accurate reflection of the activities and information actually contained in the program materials. These descriptions may, however, provide insight into the curriculum developers intentions. The program approach, including the suggested activities and their role in the pattern of instruction, needs to be clearly described based on the detailed information and materials _actually_ provided in the program.

One means of thinking of the literal program analysis relates to the notion of an information processing theory. In many respects, the SCIS program developers had to try to define the task environment for teaching the abstract science concept of ecosystems to sixth grade students. From this description, there must have been some decision concerning the components requiring attention in developing the program. These are the components the developers would consider for the teacher to perceive and attend to in their problem space during instruction. The goal of the program then, can be viewed as an effort to influence the nature of interpretation and development of these specific components -- to narrow the range of representations of these components in the problem space of the teacher. For example, given a specific set of materials for an activity, the program intends for the materials to be utilized in a specific manner. What to do (task) with a given set of materials (stimuli) is part of the given task environment for a teacher which the program hopes to influence into a specific problem space.

In a previous study (E. Smith and Sendelbach, 1977), a procedure for analysis of activity-based instructional programs was developed and applied to a portion of the SCIS sixth grade Models Unit. This procedure was based on a set of activity features including task assigned, role of the teacher, role of the student, objectives addressed, instructional strategy, and management procedures. It involved systematic review of all the program materials readily available to the teacher. For each suggested activity, evidence in the materials was sought and used in specifying the nature of each feature (see Appendix A). Use of the set of activity features assured that reasonably complete and consistent representations of each activity were prepared.

The inter-relations among the activities are reflected in their sequence, their pattern of addressing intended learning outcomes, and in the instructional strategy features. These are further highlighted by charts and figures exhibiting brief descriptions of selected features for the set of activities.

The literal program analysis is an attempt to objectively describe both the stimuli of the program as part of the task environment and of the problem space intended to be generated. Intentions here are based on the actual written program as opposed to some philosophically ideal or intended program. An objective description of the task environment seems impossible given the previous definition of task environment but yet is necessary in order to understand the effect of the program materials on the intentions of the teacher. Newell and Simon (1972) recognized this problem and state:

> "...The requirement (of objective description of the task environment) can be satisfied approximately by studying situations where the complexity is great relative to the time available to subjects for analyzing it. Then the experimenter, even if he is no more intelligent than his subjects, can meet the requirement by devoting much more time to the analysis of the situation than is available to my subject." (page 64)

The complexity of the situation and the limited time for planning and implementing the instructional content by the teacher are part of the teaching task. The analysis of the literal program, therefore, may not be "complete" but it attempts to identify all relevant stimuli and the associated intended results.

The attempt to identify all relevant stimuli and associated intended results for an instructional program requires the identification of the instructional purpose for the activities -- an activity's abjective. The specification of instructional objectives has been a point of dispute among educators. The notion of specifying the objective in terms of the behavior the student will be expected to perform after instruction has been a part of on-going debate (Gagne, 1972; Kneller, 1972; Mager, 1962; Bruner, 1960; E. Smith 1974). Most recently, cognitive psychology has further added to the debate with notions of semantic networks for representing knowledge and instructional material (Posner, 1978; Greeno, 1976). The program analysis features used in the analysis to address the notion of instructional purpose are 1) task, 2) propositional knowledge addressed, and 3) procedural knowledge addressed. These three features identify what the activity requires of the student in behavioral terms and what knowledge elements are addressed in cognitive terms. Of these three, the task feature is most significant for understanding the objective of the activity. The task feature identifies the goal or problem of an activity. Given some set of conditions and materials for an activity, the task identifies the purpose of the activity. Once the task is described, the other two features can be identified. The propositional and procedural knowledge features are components of a given task.

The following example illustrates the relationship between these three features -- task, propositional knowledge and procedural knowledge (from Literal Program Activity Analysis 12.03):

Literal Activity Text: (A) After the children have observed the results of their experiment, ask them questions similar to these. (B) What kind of gas do the tablets produce? (C) What evidence did you use to identify the gas? (D) Also ask the children to compare the results of blowing through blue BTB with those from this experiment.

Task: To determine from experimental results whether the gas produced by seltzer has some carbon dioxide.

Propositional Knowledge:

10.01.1	Gases can be identified.	
10.02.2	Observation of change is experimental data and evidence for a change having occurred.	
10.03.2	(Experimental data can be used to help form hypotheses)	Interdependence of activities and knowledge
10.07.5	BTB solution changes color from Blue to Green from interaction with some carbon dioxide and changes color to yellow from interaction with more carbon dioxide.	
12.03.1	The gas produced by a seltzer contains carbon dioxide.	

Procedural Knowledge:

10.06.4	Interpret experimental evidence to explain results.

The materials provided for this activity and the given problem constitute a bounded and defined section of the task environment for the teacher. The defined task and the propositional and procedural knowledge elements are an interpretation of the intended problem space. This is to say that there may be (and certainly are) other tasks and knowledge features which would be derived from the given task environment. The literal program analysis attempts to investigate this complex section of the task environment in a thorough and objective fashion in order better to understand its nature and later, its influence on the teacher.

Rationale for Analysis of Teacher Intentions

The section on Rationale for Analysis of Actual Classroom Instruction briefly reviewed major aspects of research on teaching. It pointed out the past emphasis given to the study of discreet teacher behavior variables, and contributions and limitations of such research. It argued for a holistic research approach to gain understanding of the classroom as a system. A similar argument can be made for the need to understand the teacher, not simply as a set of discrete behaviors, but as a thinking professional whose behavior reflects a considerable degree of intentionality. Knowledge of the teacher's intentions for instruction can provide a foundation for more informed and meaningful analysis of classroom instruction. Since teacher intentions may be both determined by and reflected in their planning, the study examined the teacher's plans and planning for instruction.

Research on teacher planning was recently reviewed by Yinger (1977), who found only a small number of published empirical studies. The earlier studies (Zahorick, 1975; Taylor, 1970) used self reporting of teachers via questionnaire and interviews to examine the decisions made or factors considered in normal planning. Later, Peterson, Marx, and Clark (1977), used a "thinking aloud" technique to study teacher planning in a laboratory setting, for a new instructional unit and unfamiliar students. The teachers' comments were then coded into categories. Morine (1976), studied the written plans prepared by teachers to teach two experimentally prescribed lessons to a subset of their own students. These plans were rated and their contents catagorized. The results of these studies indicated, contrary to most prescriptions (e.g., Tyler, 1950; Taba, 1962; Popham and Baker, 1970), that a relatively low priority was given to the specification of objectives. Major emphasis was given to the subject matter to be taught and the student activities to be used. In an intensive case study of a primary grade teacher, Yinger (1977), examined both teacher planning and the enactment of plans in the classroom. He used both ethnographic procedures and information processing psychology methods such as thinking aloud, simulated planning tasks, and judgment tasks. Instructional activities were found to be an important structural unit for both planning and classroom instruction. Features of activities identified as important in planning were: location, structure and sequence, duration, participants, acceptable student behavior (in a social sense, not in an academic sense), instructional moves or routines, and content and materials.

An important aspect of the teacher planning and the resulting classroom instruction identified by Yinger was the development of <u>routines</u> (1977, p.143). These were patterns of behavior designed by the teacher and implemented in the classroom to facilitate the day to day operation of the classroom. Yinger's study indicates that the teacher may have intentional effects on the classroom system through specific decisions about activities for a given day, as well as more indirectly through the establishment of routines.

In a previous study (Smith and Sendelbach, 1977), a simulated planning task to examine a teacher's intentions for teaching a familiar science unit to their own students was developed and tried out. Four experienced SCIS teachers were asked to plan as usual for teaching a three week portion of the SCIS Models unit in a simulated planning setting. They were asked to plan for teaching a hypothetical "new" part for the unit, using an unorganized set of activities provided. Their planning activity was video taped and the recodings reviewed with the teachers to stimulate their recall of thoughts and actions which occurred during the planning activity.

A unique aspect of the study was the development of representations of the teachers' plans. These took the form of a sequence of activities each described by the same set of features as was used to analyze the literal program. The analysis was conducted by examining the data sources for evidence of the intention to use, modify or supplement the activities included in the program materials. The use of a literal program analysis (as previously described) to provide a framework for understanding the teacher's intentions was exemplified in the study. The initial instructional activity feature set grew out of the program analysis and was subsequently revised to better account for the information obtained from the teachers. The revised activity feature set included the task assigned, teacher and student roles, specific planned or anticipated behavior, objectives, arrangement procedures, duration, and instructional strategy. (see Appendix A)

Although primarily a pilot of the research methods, the study yielded some interesting results. Consistent with earlier studies, major attention was given to student activities and materials, and to subject matter addressed. Few references were made to objectives per se. The most striking aspect of the plans encountered was their level of specificity. Despite the very sketchy written notes typically produced, the teachers had, or developed, a surprisingly detailed awareness of what they intended. Probing of teachers' thoughts as they made notes or reviewed materials frequently elicited references to what they and their students usually do in a specific activity. Largely undocumented on paper, these plans-in-memory seem to be available to experienced teachers as needed for further planning, preparation and actual teaching.

As reflected in pilot ethnographic field work with one teacher from the planning study, classroom instruction may deviate from the teacher's intentions -- sometimes even in ways of which the teacher may not be aware (Sendelbach, 1978). However, on the basis of the existing research, it seems clear that the teacher's classroom behavior can be understood as an effort to implement, modify or even replace planned activities. Thus, prior knowledge of those intentions is an important foundation for ethnographic fieldwork in the classroom. The need to understand whether modifications to the literal program observed during actual instruction are part of the teacher's intentions and are due to their efforts, can best be understood by including an analysis of the teacher's intentions.

CHAPTER III

DESCRIPTION OF THE STUDY

Design

The study to be described employed a case study approach. Three focal points were addressed: the literal program, the teacher's intentions, and the actual classroom instruction. The study sought to describe and understand each of the focal points and their inter-relations. Each point required a distinct mode of inquiry which resulted in a moderately high level of complexity for the whole study.

The Teacher and Students

One sixth grade teacher and two of her classes constituted the case studied. The school was selected from a school district in mid-Michigan, and was representative of that district. The teacher had one year of previous experience teaching the Ecosystems Unit, and was recognized as a successful SCIS teacher by the district's science supervisor. The selection of a teacher was made in an attempt to tap the expertise of an experienced classroom teacher in order to aid in identification of their repeated and therefore internally appropriate and successful innovations. Also, the use of the program for the first time was considered to be special case somewhat unrepresentative of the pattern likely to develop over a period of repeated use.

Procedures

The purpose of this study was to investigate the three focal points of interest. Identification of modifications a teacher intended from a given literal program for instruction and why such modifications were made are addressed. The study also identified what modifications were made from the teacher's intended instruction in actual instruction, and again, accounted for why the modifications were made. Recently developed and exisiting procedures (described in the following sections)were used to investigate each of the research questions presented above (p. 17).

Analysis of the Literal Program

The analysis covers "The Oxygen-Carbon Dioxide Cycle", "Part Three" of the SCIS sixth grade unit, Ecosystems (to be referred to as Part Three). Since instruction in the SCIS program is activity-based, the unit of analysis was the instructional activity. The analysis of individual activities employed a set of activity features (see Activity Features, p. 65) based on a similar set developed in a pervious study (Smith and Sendelbach, 1977). The analysis used all relevant information in the Ecosystems Teacher's Guide (SCIS, 1971) to prepare descriptions of each feature of each activity suggested for Part Three. These descriptions constitute the major product of the analysis.

The interrelations among the activities is indicated by their sequence, by the objectives addressed, and more explicitly, by the descriptions of strategic functions of each activity. In addition, summary charts including brief descriptions of selected features are presented to facilitate comparison with similar summaries of the teacher's intended approaches and actual classroom instruction.

The objectives addressed by the activities are represented by specifying the propositional and procedural knowledge to be learned and uses that the student is expected to be able to make of that knowledge.

The program analysis documentation includes a detailed description of the procedures, the summaries and discussion, the results of the investigations and their implications. Samples of the analysis of activities are included in Appendix A. A complete set of each activity is included in Technical Report 091578. The detail of the actual procedures used for the analysis are described in the Analysis of the Literal Program section of Chapter Four. The purpose of the procedures was to present a description of what each activity for instruction would be like as described by the program materials.

Analysis of the Teacher's Intended Approach

The teacher's intentions for instruction are viewed as an important influence on actual classroom instruction.

*Note: Technical Report 091578 available on request from the Science and Mathematics Teaching Center, Michigan State University.

Furthermore, to gain an understanding of the teacher's classroom behavior requires knowledge of their intentions. To study the case teacher's intentions for instruction, her plans and planning for "Part Three" are examined using the Science Teacher Planning Simulation system. This system video-taped the teacher while engaged in planning for instruction of the given unit. The planning took place in the classroom at the time the teacher indicated she would normally plan. The videotape equipment was taken to the classroom in order that planning occurred as normally as possible. After each planning session, the teacher reviewed the video-tape with the researcher to stimulate recall of her thoughts during the planning process (Kagan, et al, 1976). Four such sessions were required to plan for all of "Part Three". Each session required approximately three hours. The activity description from the literal program analysis provided a basis for probes by the researcher during this review.

The stimulated recall part of the Science Teacher Planning Simulation System was included in order to understand what the brief and often cryptic written lesson plan produced meant to the teacher. This process also provided information about the nature of the planning process for the teacher. Appendix B contains the instructions for the stimulated recall procedures as they were used in the study along with general probes used by the researcher to encourage conscious recall.

The analysis of the recorded protocols from the planning sessions, involved an analysis procedure similar to the one used in the analysis of the literal program (Smith and Sendelbach, 1977). The framework for analysis began with the same initial set of activity features as the program analysis. These features were essentially used as an initial set of questions about the teacher's intentions. As the analysis progressed, hypotheses about both the teacher's intentions and planning process were developed. The data sources (protocols and artifacts from the planning sessions) were systematically reviewed to develop a preliminary profile of the features, refine the initial questions about the plans, refine proposed hypotheses, and seek further confirming or disconfirming evidence for those hypotheses. The "confirmed" analysis is represented in detailed descriptions of the teacher's planned activities and generalizations about the teacher's intentions. These descriptions and generalizations constitute the major part of the analysis of the teacher's intentions and are part of the Teacher's Intentions for Instruction Analysis section of Chapter Four. Examples of the stimulated recall analysis record are also included in Appendix B.

Analysis of Actual Classroom Instruction

The phase most crucial in the teaching-learning process is the actual classroom instruction. The importance of instruction is directly related to what many consider the primary goal of education -- the outcomes the students acquire. Student learning is primarily derived from instruction in the classroom. In order to determine what actually occurs during instruction, the methods of ethnographic field work were used.

As previously described, ethnographic research is methodologically pragmatic, making use of any number of research procedures, strategies and operations designed for getting answers to questions about events of interest. Although participant observation was the basic strategy, this was supplemented by interviews, classroom video taping, and teacher logs. Each daily lesson in the five week unit on the "Oxygen-Carbon Dioxide Cycle" was observed. Field notes from these observations provided a primary source of data and analysis. Appendix C contains examples of the daily field notes.

One characteristic of ethnographic procedures is that the researcher is not confined by a priori data categories. This does not mean, however, that the researcher has no initial perspective. Typically the perspective is based on the researcher's background and experience. As indicated above, this can result in very different frameworks for analysis as occurred in the C.S.S.E. project. For this study the perspective obtained from the literal program analysis and on-going teacher intention analysis provided many of the initial questions to be investigated in the classroom. There was a critical balance between prior knowledge as a useful tool and prior knowledge obscuring the observation of actual interactions. As data was gathered the interactions that constituted the teaching-learning process for this instruction were described and initial analysis and explanation proceeded.

Classroom video taping was done for four instructional periods. This provided a data source for micro-analysis of the classroom and a record to compare and supplement field notes. Appendix C contains a sample of video tape analysis.

The teacher's perception of the teaching-learning process influences the nature of that process. In order to gain insight into this perception and impression, the teacher was asked to make an audio log prior to and following each teaching session. The instructions to the teacher involved the teacher providing a brief description of the intended instruction and an account of actual instruction. The teacher was also asked to identify factors seen as causing modification during instruction from intentions. This procedure was intended to provide a supplement to the data base concerning the teacher's plans obtained from the simulated planning session. Furthermore, this technique was to provide a daily account of instructional features salient to the teacher. The procedure was piloted in a recent investigation of changes in a teacher's actual instruction from planned intentions (Sendelbach, 1978).

The audio log procedures were unsuccessful for this study. As the teacher started the procedure the report of intentions for instruction were mere readings of the cryptic notes from the lesson planning book. Similarly, the report of actual instruction was very non-descriptive. As the study progressed, the teacher discontinued all audio log reports stating that the procedure was not convenient given time restrictions and other demands of the classroom.

How the students engage in the instructional activities influences the content addressed. The literal program analysis provided the background knowledge of the potential nature of the instructional activities including the task. Since routines appeared to be a feature of teachers in planning and in actual classroom instruction (Yinger, 1977, and Florio, 1978), an analysis of instructional routines was part of the analysis procedure in order to understand the nature of instructional activities.

A notion of the teacher's instructional routines was first obtained from the planning sessions. This perspective of routines, however, only represented routines addressed during planning and was interpreted through the intentions of the teacher. Direct observation was necessary to determine actual classroom routines and their effects on the teaching-learning process. The manner of structuring the activity by the teacher -- the teacher's review and explanation of the relationship of current activities to previous activities, directions for the activities, statement of objectives, or clarification of an activity's content -- may affect student cognitive organization for the activity. How the students were organized for the activity -- pairs, individually, small groups, whole class -- may also be significant. These features of instruction, some identified from previous research on teaching, were all part of the researcher's perspective in investigating the teaching-learning process. Those determined to be most salient are reported in the findings.

In summary, the continuous analysis, hypothesizing, and theory development along with an open mode of inquiry which are part of the ethnographic procedure produced a characterization of and an accounting for the actual classroom instruction. The end product of this analysis is the development of theory, grounded in the observed classroom interactions, which contributes to accounting for the observed teaching-learning process.

Limitations of the Study

It is realized that this study has limitations with respect to generalizable implications since it is a case study involving one teacher, in one class, teaching a five week instructional sequence from one science program. Implications extending beyond this instructional sequence or teacher must be very carefully considered. No classroom, teacher, or curriculum, however, is totally unique and therefore some findings may relate to other classes, teachers, and curriculums. The orientation was one of first determining what was going on concerning activity-based science instruction and then determining what this was representative of. The generalizations, therefore, are based on actual observations. The events of the classroom are actual, the regularities and consistencies are there too, but were for the researcher to discover.

Generalization, therefore, does not relate to the statistically derived notion, but to what has been referred to by Stake as "naturalistic generalizability". Stake clarifies this difference:

> "A case is often thought of as a constituent member of a target population. And since single members poorly represent whole populations, the case study is seen to be a poor basis for generalization. Often, however, the situation is one in which there is a need for generalization about that particular case or generalization to a similar case rather than generalization to a population of cases. Then the demand for typicality and representativeness yield to needs for assurance that the target case is properly described. As readers recognize essential similarities to cases of interest to them, they establish the basis for naturalistic generalization."(Stake, 1978)

Given multiple studies or information that some events in this given case were not unique, the potential to generalize increases. Wherever the reader recognizes essential similarities, there may be a basis for naturalistic generalization. Wherever possible, this study draws upon past and concurrent efforts and results. This is consistant with the ethnographic methodology. The limitations of generalizable implications, however, must be understood.

Summary Analysis

Each of the analyses previously described have implications by themselves. The design of the study was founded on the necessity for looking at all three of the components to determine the degree to which there is interaction. The final effort, therefore, involved a summary of the data from each of the individual components of the study. The nature of the summary analysis was the development of a unifying model relating all three components of the study: the literal program, the teacher's intentions, and actual classroom instruction.

CHAPTER IV

ANALYSIS OF THE DATA

Introduction

The purpose of this chapter is to report the analysis of the data generated from the study. The data relate to the three major components identified in Chapter One: The literal program, the teacher's intentions, and actual classroom instruction. The results and analysis of the literal program, "Part Three: The Oxygen-Carbon Dioxide Cycle" from the SCIS Ecosystem unit was done as an independent component. This identification of the activities and their features was completed prior to beginning either of the other two components.

The teacher's intentions and actual instruction components of the study were hypothesized to be interrelated and interacting. Distinct times were identified and procedures used for collecting data relating to the two components. For analytical simplicity and clarity, the results of the analysis of the teacher's intentions are presented as a seperate section. This analysis is based only on the data obtained from the procedures used to investigate the teacher's planning. The analysis attempts to identify the content and nature of the teacher's intentions and of the planning process. Chapter Five, "Summary and Conclusion", presents a model developed from synthesizing the results of the whole study and describes the relationship between the planning process and actual instruction.

The analysis of actual classroom instruction addresses the question of what actually occurred in the classroom. While ethnographic procedures were used to investigate this component of the study, the researcher had a very detailed, rich, and specific perspective from the investigation of the other two components (see: Procedures, Analysis of Actual Classroom Instruction, p. 51). This perspective influenced both the selection and analysis of the data collected. This influence is an unavoidable characteristic of the ethnographic research process (Erickson, 1977). The following analysis, therefore, attempts to address the five "test questions" identified by Erickson:

1. How did you arrive at your overall point of view?
2. What details did you leave out and what did you leave in?
3. What was your rationale for selection?
4. From the universe of behavior available to you, how much did you monitor?
5. Why did you monitor behavior in some situations and not in others? (p. 17)

The fundamental question in the analysis of classroom instruction was: What actually happens in activity-based science instruction? Within this broad question, the analysis attempts to relate and examine what actually happens within the perspective of the analyses of the literal program, the teacher's intentions and the context of the classroom. Wherever possible, the analysis attends to the requirements of the test questions.

A) Analysis of the Literal Program

The analysis of "Part Three: The Oxygen-Carbon Dioxide Cycle" of the SCIS program was done in order to determine what instruction would be like if the program were taught as described in available program materials (primarily the Teacher's Guide and the Student Manual). This analysis is labeled the literal program as it is meant to represent the way the program indicates actual instruction should occur. It became a major component of the researcher's perspective and point of view in the collection and analysis of data. Analysis of the literal program provides a reference point for comparing the way the teacher uses and modifies the program.

Nature of the SCIS Program

The SCIS science program was developed during the 1960's through funding by the National Science Foundation. In contrast to the traditional textbook based science programs, SCIS was designed to directly engage the student in investigating phenomena in the classroom in an organized manner. The program is inquiry centered and conceptually structured (Ecosystems Teacher's Guide 1971). It is designed to integrate the content, process, and

attitude factors of learning. While attitudes are important -- grossly stated as the formation of positive attitudes toward science -- this analysis focuses on the content and process factors. The attitude factor is primarily met by the program's attempt to engage the students in activities and manipulation of materials. Students are to develop an appreciation of scientific inquiry and experience enjoyment in this process. A positive student attitude toward science is to result.

An important characteristic of the SCIS program is the organization of materials into what the developers call "the learning cycle" (<u>Ecosystems Teacher's Guide</u>, 1971). This cycle involves three stages: exploration, invention, and discovery. The stages in the cycle are sequential and have unique characteristics. "Part Three" represents a complete cycle of exploration, invention, and discovery. The <u>strategy feature</u> in the literal program analysis identifies the nature of each activity according to the characteristics of these three stages (see Appendix A).

The inclusion and identification of the learning cycle in the program is important since each of the three stages involves different roles for the teacher and students. In the exploration stage, the teacher is to provide the students the opportunity to spontaneously handle and experiment with objects to see what happens. During invention, however, the teacher is much more centrally involved. This stage involves the identification and development of new subject matter content knowledge. For "Part Three", the concept of the carbon dioxide-oxygen cycle is specifically identified and developed. Finally, the discovery stage involves the students relating the subject matter content knowledge developed in the invention stage to new applications. For "Part Three", this means applying the oxygen-carbon dioxide cycle to terrestrial plants as well as aquatic plants.

The SCIS program is divided into a physical science sequence and a life science sequence. Six basic units are designed in each sequence -- one for each of the grades, one through six. Further elaboration of the nature of the SCIS program is done through examination of the specific unit of interest in the following sections.

Sixth Grade Ecosystems Unit

The sixth grade Ecosystems unit is the focus of this analysis. This unit is the life science sequence for the sixth grade and is of particular interest since it is intended to achieve a synthesis of the student's investigations from the previous life and physical science sequences. The unit consists of five parts:

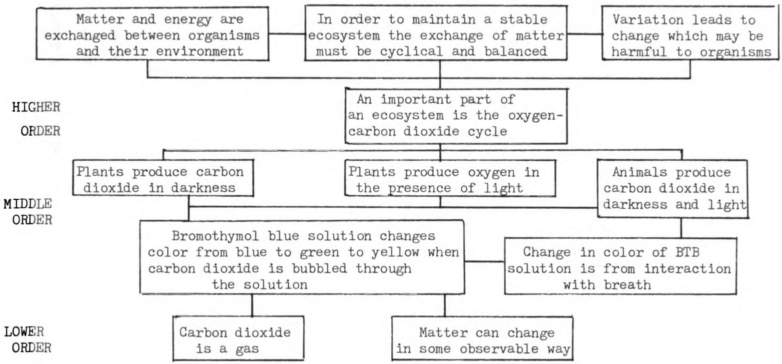
Part One:	Classroom Ecosystems
Part Two:	The Water Cycle
Part Three:	The Oxygen-Carbon Dioxide Cycle
Part Four:	Cycles in an Ecosystem
Part Five:	Pollution

Each of these parts are intended to address three main propositions: 1) matter and energy are exchanged between organisms and their environment; 2) in order to maintain a stable ecosystem the exchange of matter must be cyclical and balanced; and 3) variation leads to change which may be harmful to organisms (Ecosystems Teacher's Guide, 1971). If propositions are thought of in a hierarchical sense from simple or specific to complex or general, these three propositions would occupy an upper level of complexity which subsumes propositions of a more specific nature addressed in lower levels. The notion of a hierarchy of propositions is further exemplified in examination of any of the five parts of the unit. This analysis examines "Part Three".

"Part Three: The Oxygen-Carbon Dioxide Cycle", is the specific part of the Ecosystem unit of interest in this analysis and clearly shows a hierarchy of propositions. The three upper level propositions, previously stated, can be addressed through investigation of the oxygen-carbon dioxide cycle in an ecosystem. A step down the hierarchy, the proposition of the oxygen-carbon dioxide cycle also requires development. Subordinate to the oxygen-carbon dioxide cycle are propositions such as plants produce oxygen in sunlight, plants produce carbon dioxide in darkness, and animals produce carbon dioxide in sunlight and darkness. Continuing down are such propositions as bromothymol blue solution (BTB) changes color from blue to green to yellow when carbon dioxide is bubbled through the solution. Figure 4-1 shows the relationship of these propositions in a hierarchy. One of the fundamental notions in the hierarchy as shown in the figure is that an understanding of the lower order propositions is prerequisite to an understanding of the middle and higher

FIGURE 4-1

HIERARCHICAL RELATIONSHIPS BETWEEN PROPOSITIONS



order propositions. The analysis of "Part Three" was designed to indicate the development of higher order propositions and their interrelationships as the part is described to be taught. There was the assumption that in fact there should be evidence that these propositions are addressed in a sequential and progressive fashion. The following sections describe the procedures and rationale for the analytical approach.

Unit of Analysis: Activities

As stated previously, the SCIS program was designed to engage the student in investigating phenomena in the classroom in an organized manner. The purpose of this analysis of the program materials is to identify what phenomena the students investigate and the nature and organization of the investigation. The unit of analysis selected was the activity. An activity is a segment of instruction which is part of a larger unit of instruction. A classroom period of instruction can involve a number of individual activities. Each chapter within the unit also consists of numerous activities. For example, Chapter Ten: "Breath and BTB", consists of twelve activities and is suggested to be completed in less than one class period.

Such a small unit of analysis provided a means for being able to compare the teacher's intentions to the literal program in order to determine what is included,excluded, and modified. The activity also provided a useful context in which to reflect classroom observations.

The actual program materials are not presented with explicit identification of activities as used in this analysis, but are presented in written prose. The fundamental problem of the analysis is translation of the presented program text into individual activity units. Just what constitutes an activity and distinguishes the end of one activity from the beginning of the next activity becomes the first step of the translation. This issue is addressed in the following section.

Anatomy of an Activity: Activity Features

Past research involving program analyses, analyses of teacher's intentions for instruction, and analyses of actual instruction has made use of activity features (Smith and Sendelbach, 1977; Sendelbach, 1978). Activity features are the component parts of an activity. The component features of an activity include:

- the task,
- the teacher's role and planned behavior,
- the student's role and anticipated behavior,
- the knowledge addressed,
- the instructional strategy, and
- the management

The features made it possible to account for all the information available within the program and to relate the teacher's intentions and actual instruction. The features were determined in order to adequately address the following set of fundamental questions:

1. What is to be done? (the task)
2. What is needed to do what is to be done? (materials)
3. Of what is to be done, what do the students do? (student role and anticipated behavior and management)
4. Of what is to be done, what does the teacher do? (the teacher's role and planned behavior)
5. From what is to be done, what is to be learned? (knowledge addressed)
6. How does this fit into the SCIS learning cycle? (strategy)

Clearly, identification of such features in the other two components of the study provided valuable information about the what of the teacher's intentions and the actual instruction -- a descriptive analysis. The what only constitutes part of this research. Other segments of the analysis inquire into the why and so what of the activities which were intended and which actually occurred. The features identified in the analysis provide a means for clear identification of possible modification of the actual program. A teacher may modify one feature of an activity and not others. Such modifications can be more clearly identified with the feature scheme.

Each activity consists of a unique set of features. The identification of an activity, therefore, relates to the change of a feature in the program prose. A change of activity was found most often to be identified by a change in one of three activity features:

- task
- teacher's role and planned behavior, or
- student's role and anticipated behavior.

If any of these features or any of the other features change, there is a transition from one activity to another activity. For example, in Chapter 10 the "Teaching Suggestion" section of the Teacher's Guide begins:

> You might introduce this activity by explaining that over the next few weeks the class will experiment with gases taken in and given off by organisms. Ask the children if they know of a test to identify the gases. If they have had experience with BTB in previous SCIS units, they might suggest repeating those activities.
>
> Explain that each child should fill a cup half full of water and add about twelve drops of BTB to it (or obtain one-half cup of the solution you prepared.) Because the angle at which the bottle is held affects the size of the drops, the blueness of the children's solutions may vary. Rather than trying to perfect the children's technique, let this difference be a variable that the children identify later.
>
> Tell the children to exhale through straws so their breath bubbles slowly and gently through the BTB solution. Ask them to look for evidence of a change, but do not tell them what to expect.(p. 62)

This text segment involves two activities, (activities 10.01 and 10.01) since there are two different teacher and student roles described as well as two different tasks. The first paragraph involves an activity where the teacher's role is discussion leader and the students' role is a discussion participant. These roles are determined from the text which suggests a discussion of a test to identify gases from previous SCIS units. A shift occurs in the second paragraph. The teacher's role is changed to provide instructions and the student's to listen to instruction. These roles are different from the roles assumed during a discussion. There is also a shift in the task feature from the text. At first, the students' task is to recall past activities where BTB solution was used to identify gases. Later their task is to understand instructions being given by the teacher.

Explicit to Implicit: A Continuum

A complete description of an activity involves identification of each of the activity features (see p. 65). If a feature is not identified from the program materials, it must be developed by the teacher or the students, since an activity cannot occur without all the features. The identification or awareness of each feature may not be conscious for the participants but each feature must occur.

Analysis of the text material for identification of activity features required some level of inference. The text shown previously from Chapter 10 (see p. 67) does not explicitly define the teacher's or students' roles. Their roles, however, could be inferred from the text identification of verbal interaction between the teacher and students -- "Ask the children if they know... they might suggest...". The identification of the teacher's and students' roles in this activity required a very low level of inference. The translation from text to activity feature was direct with explicit reference for the translation available in the text.

Not all activity features translated as easily from the text. For some features, a greater degree of inference was required.

Some features were implicit from the text. As in all communication, the level of inference required for translation varies from interpreter to interpreter. A major task of this analysis was to provide the references used for translation of the text to activity features. This point was especially important for the <u>knowledge addressed</u> feature.

The knowledge addressed feature has two parts: propositional knowledge and procedural knowledge. Propositional knowledge is knowledge of the content factor of the program -- knowing the <u>what</u> or <u>that</u>. Procedural knowledge is knowledge of the processes from the program -- knowing <u>how</u>. Both types of knowledge are addressed in the program but are usually not explicitly stated. They require a level of inference.

Propositional knowledge composes the majority of knowledge addressed in "Part Three". A proposition is a statement which is either true or false given the current conception of the nature of the world. The statement, "Plants produce carbon dioxide in darkness", is an example of a true proposition. The identification of proposition addressed by each activity required analysis of the concepts and their relations (context) in the text. Reference statements indicating the evidence for each proposition identified in the analysis are provided for two reasons. First, these references allow for examination of the validity of the translation to the proposition to be examined. Second, the references provided a source of information about the sequence of propositions. This was needed for analyzing and relating propositions and the development of the program's conceptual structure (previously identified as conceptual hierarchy) (see p. 62).

The Independence/Interdependence Relationship

The activity analysis as described involved an important relationship of the activities. Each activity is a component of the program and has a complete set of features. Furthermore, specific propositional and procedural knowledge can be identified as a feature of most activities. These two notions indicate an independent nature of the activities and their features in the program materials. The hierarchial nature of the concepts addressed and the relationships between these concepts, however, reflects the interdependence of the program's conceptual scheme. In addition, the activities are often dependent upon each other -- e.g. a discussion of experimental results activity is dependent on a preceding activity which produces the experimental data to be discussed.

This interdependence provides additional rationale for including the references to the activities and their associated features. These references were also useful for understanding the organization of the program and later in the analysis of the teacher's intentions and actual instruction.

Procedure for Activity Analysis

The following procedure was followed in activity analysis:

1. Read the complete chapter in the Teacher's Guide including the "Objectives" and "Teaching Materials".

2. Identify each activity in the chapter by starting with "Teaching Suggestions". The first activity continues until there is a change in an activity feature -- usually the teacher's or students' role or the task. Continue until all activities are identified for the complete chapter.

3. After the activities of a chapter were identified, the features of each activity were identified. This was done by 1) reading the complete activity and 2) determining which activity feature(s) are most explicitly stated and transfer them to the Activity Analysis form in the appropriate feature space. For the two category features, Student and Teacher, if either the Role or Behavior parts of the features were explicitly identified, the whole feature was completed (i.e., if Behavior was explicitly identified but not the role feature, Role was inferred from the identified behavior). After all explicitly identifiable activity features were designated, the unidentified features were reviewed to see if any could be inferred from an already identified feature (i.e., if the Teacher's General

Role is discussion leader, one can logically infer the Student Role to be a discussion participant). For activity features still unidentified "not specified" is placed in the feature place. Inferred features are identified with parentheses.

4. Where necessary, particularly with the Knowledge Addressed feature, the sources for each proposition are identified after the proposition is identified. If previously addressed knowledge propositions are addressed in an activity or are subordinate to an activity's addressed proposition, the prior proposition number is referenced.

Sample Activity Analysis

"Part Three" was analyzed according to the feature scheme discussed above. A sample of an activity analysis follows along with a narrative of the analytical process. The activity analyzed is from chapter ten "Breath and BTB". First the segment of the Teacher's Guide addressing the activity was identified. The text material is very linear, presenting information concerning activities in a sequential fashion. The Literal Activity Text for the sample activity is from page 62:

> When the children see a color change from blue to green, ask if the solution will continue to change color or what will happen if they continue to blow. Will the solution turn a different color if it is stirred while they are exhaling into it?

This is the third activity in chapter ten and is therefore named in part 10.03. An additional identifier is added to the name related to the Task of the activity:

1. Activity Name: 10.03 - Identify change in BTB solution from interaction with exhaled breath.

The next feature identified from the text is the task. The task identifies the problem for the activity and a general notion of the goal. For this activity, the task was translated as being:

4. Task: Given a cup half-full of BTB solution, observe any changes which occur when you exhale bubbles through the solution with a straw and predict additional changes.

The literal text previously cited for this particular activity is not the only relevant information. Other information of particular relevance to some activity feature is identified.

3. Other References: Activity 10.02. Chapter Objective: "Children blow through solutions of BTB and observe that they change from blue..." Part Three objective: "to use data to verify hypotheses..." Preface: "You will find that you will play two complimentary roles as the teacher of this unit: You are both an observer who notices how well the children progress in their investigation and a guide who helps them to relate their observations to key scientific concepts." (p.4)

From the task and other reference features the knowledge addressed by the activity can be identified. This feature is divided into two parts as stated previously, propositional knowledge and procedural knowledge. The primary source for each knowledge element is identified after each element.*

---

* References identifying the sources of information for a determined feature are always included between double slashes.

5.1 Propositional Knowledge: 10.03.1 BTB solution changes from its blue color when breath is bubbled through. // From Text and chapter objective.// 10.02.2 // 10.02.2 interdependence//

5.2 Procedural Knowledge: 10.03.2 (Experimental data can be used to help form hypotheses) // From "Part Three" objective//

10.03.3 Observe features of materials (i.e., BTB solution is blue) // From text //

10.03.4 Observe bubbles going through the solution // From text //

10.03.5 Observe materials for feature change. // From text //

After the above features have been identified, the identification of either the student or teacher features can be addressed. From the literal text, information is provided with respect to both features so the order of their identification is inconsequential. Both features are also divided into two elements: general role and anticipated behavior. Again, reference is provided after each identification in order to support the interpretation.

7.0 Student
7.1 General Role: Engage in procedures given in activity 10.02. // Activity interdependence//
7.2 Anticipated Behavior: None specified

8.0 Teacher
8.1 General Role: Circulate and question. // From Preface //
8.2 Planned Behavior: "When students see a color change (in the BTB), ask if the solution will continue to change color or what will happen if they continue to blow. Ask if the solution will turn a different color if it is stirred while they are exhaling into it."

The SCIS program was designed with a learning cycle consisting of three phases: exploration, invention, and discovery (see Nature of SCIS Program, p. 59). The strategy feature of the analysis identified the nature of the activity according to the definition of these three phases and its context.

6. Strategy: Exploration of change from bubbling exhaled breath through the BTB solution // From strategy 10.02 and Teacher Role //

The management feature identifies the fashion of student arrangement for engaging in the activity. This feature is determined from the literal activity text. Since the students are all supplied with their own materials, the management for the activity is for each student to work individually.

10. Management: Individual

The last feature, materials, is identified from the literal activity text and the "Teaching Materials" part of the Teacher's Guide. The specific materials and their quantities identified are for the specific activity only.

9. Materials: Plastic cups
BTB solution
Straws

The identification of each of these ten features for each of the activities in "Part Three" is contained in Appendix A - Literal Program Activity Analysis.

The analysis of "Part Three: The Oxygen-Carbon Dioxide Cycle" of the SCIS program was done in order to determine what instruction would be like if the program were taught as described in available program materials. This analysis is labeled the literal program as it is meant to represent the way the program indicates actual instruction should occur. It became a major component of the researcher's perspective in the collection and analysis of data. Analysis of the literal program provides a reference point for comparing the way the teacher uses and modifies the program.

The activity analysis framework is an attempt to more explicitly and completely define the teacher's task environment and desired problem space. Appendix A contains this very specific and defined level of representation of "Part Three". The what, how, and why for each activity is defined according to the activity feature set.

Activity Type

Activity based instruction is characterized by involving students in the manipulation of materials. The literal program was seen to have a series of activities which address: 1) what is going to be done, 2) how to do what is to be done, 3) doing what is to be done, and 4) why one bothered doing what one did. While this is obvious now, this pattern and nature of activities did not become apparent until actual observation of instruction. By having the analysis of the literal program completed, it was possible to note the inclusion, modification, and exclusion of activities from the program while observing instruction. With this data base, the analysis of that instruction led to the re-analysis of the activities with the framework of activity types. This "discovery" is further detailed in the analysis of actual instruction section.

The activities as defined in the literal program analysis, address one or two of these instructional functions. For example activity 10.01 can be classified as an activity primarily addressing the "what is going to be done" function. This is evident from the Teacher's Planned Behavior feature (see Appendix A). Activity 10.02 is an activity addressing the "how to do what is to be done" function as evident from both the Task and Student and Teacher General Role features. Activities 10.03 and 10.04 are activities addressing the "doing what is to be done" function, again evident from the Task, Student General Role features. Finally, activities 10.05, 10.06, 10.07, and 10.08 are addressing the "why one bothered doing what one did" function. These four activities are distinguished from the other three type of activities in the nature of the Task and the Student Teacher roles. Chart 4-1 shows the classification of the activities in "Part Three" and Figure 4-2 shows the sequence of activities and their functions. The sequence of the activities corresponds to the function of the activities. When a new idea is being introduced for investigation such as in 10.01 (introduction of the notion of investigating gases taken in

Chart 4-1

ACTIVITY INSTRUCTIONAL FUNCTION CLASSIFICATION*

	WHAT	HOW	DOING	WHY
10.01	X			
10.02		X		
10.03			X	
10.04		X	X	
10.05				X
10.06				X
10.07				X
10.08	X			X
10.09			X	
10.10				X
10.11				X
10.12		----Cleanup---		
11.01	X			
11.02		X		
11.03			X	
11.04			X	
11.05			X	
11.06				X
11.07	X			
13.01		X		
13.02			X	
13.03				X
11.08			X	X
11.09		----Cleanup----		
12.01	X	X		
12.02			X	
12.03				X
12.04		----Cleanup----		
14.01	X			
14.02		X		
14.03			X	
14.04			X	
14.05			X	
14.06			X	
14.07				X
14.08				X
14.09		----Cleanup----		
14.10			X	

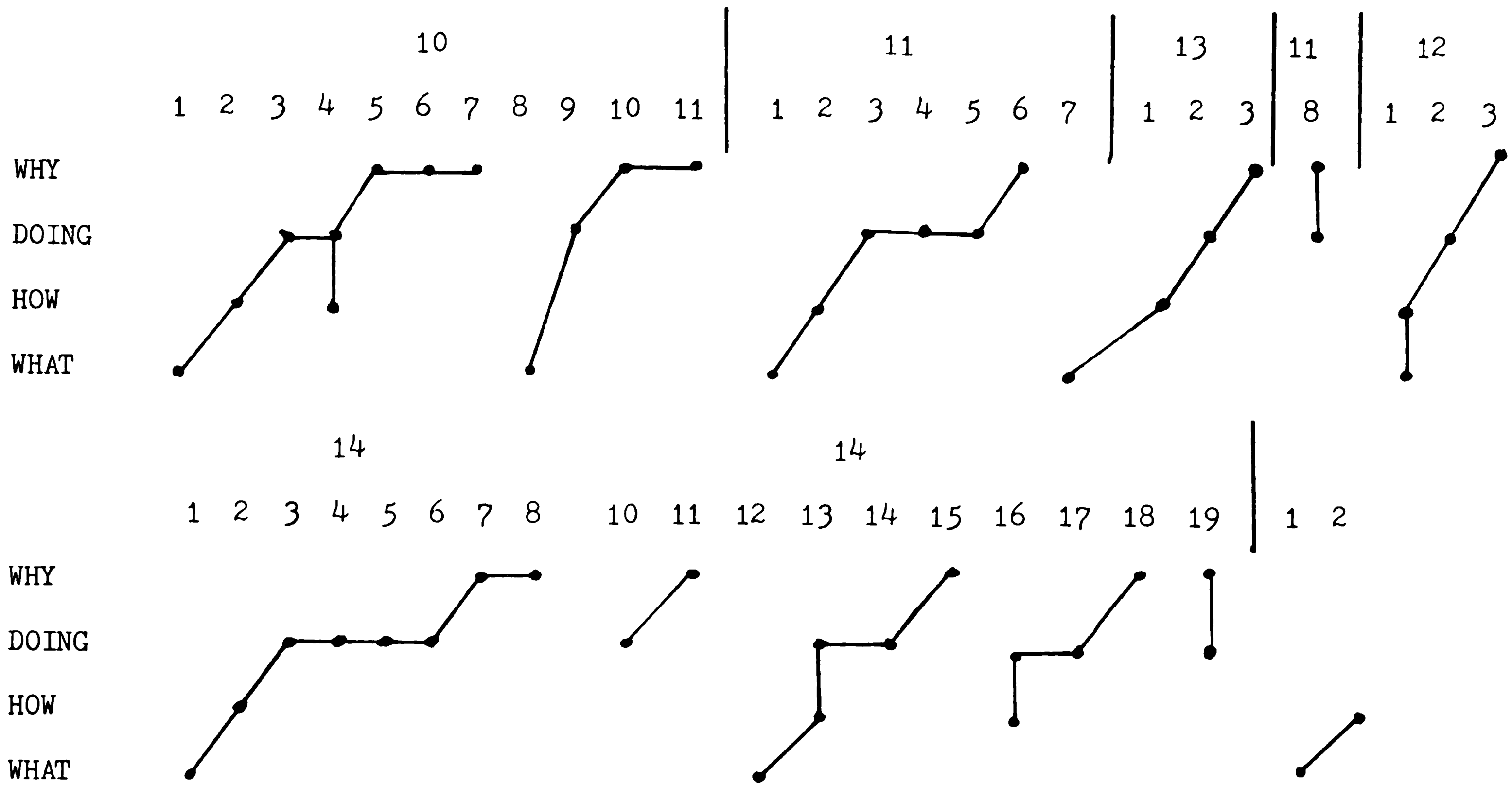
Chart 4-1 (cont'd)

	WHAT	HOW	DOING	WHY
14.11				X
14.12	X			
14.13		X	X	
14.14			X	
14.15				X
14.16		X	X	
14.17			X	
14.18				X
14.19			X	X
14.20		----Cleanup----		
15.01	X			
15.02		X		
15.03			X	
15.04			X	
15.05				X

* Activities are sequenced according to the order suggested from the Teacher's Guide.

FIGURE 4-2

FUNCTIONAL SEQUENCE OF ACTIVITIES



and given off by the organisms), 10.08 (introduction of new problem using BTB solution), 11.01 (introduction to overnight color change of BTB solution, and so on for activities 11.07, 14.12, 15.01, a what activity is used.

After a what activity, which is an introduction to an idea or issue to be investigated, comes a how activity. These activities essentially identify the means and procedures to be used in the investigation. Doing activities follow the how activities and involve implementing the identified procedures. Finally, why activities follow the doing activities and attempt to develop knowledge element specifically relating to the issue or idea presented originally in the why activity. This trend is consistent through "Part Three". Where a new issue or idea is not presented but additional investigations are done on an already presented notion, the sequence only cycles back to the how level of the sequence (as with 12.01, 14.01, and 14.16).

This notion of activity types is very relevant to the analysis of the teacher's intentions and the events of actual instruction and will be addressed in related sections.

Activity Sequence and Instructional Unit

The unit of the literal program analysis, the activity, can be grouped into a larger instructional unit -- a classroom instructional period. An instructional period is defined as a group of activities taught by the teacher or attended to by the students in one session. Figure 4-3 shows the activity sequence and grouping as identified from the literal text. Accordingly "Part Three" requires thirteen instructional segments Evidence for these instructional segments was considered to be references such as statements "The next day..." (activity 14.06-B) and "On another day..." (activity 14.10-A).

In many respects, these segments can be thought of as molecules composed of various atomic parts (the individual activities). As in many chemical reactions, the order of collision, orientation, and energy of interacting atoms is critical to molecular formation -- so with the activities in an instructional segment. Not only do the given activities have the already defined sequence, they also have characteristics (features) which, when present, result in a larger entity.

Examination of the propositional knowledge feature of activities illustrates this activity interrelationship and development. The thirteen activities composing segment one of instruction present eighteen different propositional knowledge elements. Of these eighteen, ten relate directly to and develop the concept of the interaction between BTB solution and carbon dioxide. These ten propositions are presented in an increasing complex conceptual network as shown in Figure 4-4. The figure shows how activity 10.01 involves the verbal presentation of the proposition, "A means for identifying the gases is by bubbling through BTB solution. One gas can be identified." (10.01.3). This proposition then provides the general rationale for the students making observations and generating propositions in

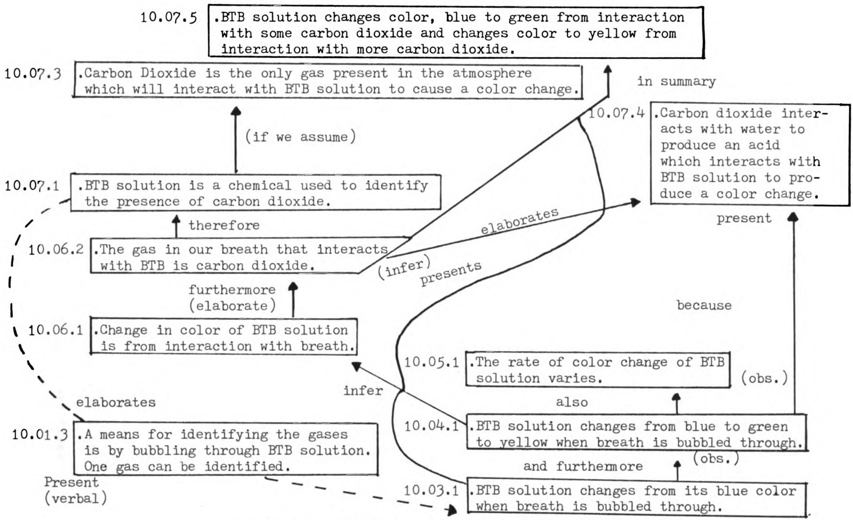
Figure 4-3

ACTIVITY SEQUENCE AND GROUPING

Group 1 10.01 thru 10.12/12.01	Group 2 12.02/12.03/12.04/11.01/11.02/11.03	Group 3 11.04/11.05/11.06/11.07/11.08	
Group 4 13/01/13.02/13.03	Group 5 13.04/13.05/13.06	Group 6 14.01/14.02/14.03/14.04/14.05	
Group 7 14.06/14.07/14.08/14.09/14.10/14.11	Group 8 14.12/14.13	Group 9 14.14/14.15/14.16	Group 10 14.17
Group 11 14.18/14.19/14.20	Group 12 15.01/15.02/15.03	Group 13 15.04/15.05/15.06	

FIGURE 4-4

LOGICAL AND SEQUENTIAL DEVELOPMENT OF KNOWLEDGE PROPOSITIONS



provides general rationale for making observation of BTB activities 10.03, 10.04, 10.05 such as "BTB solution changes from its blue color when breath is bubbled through" (10.03.1), "BTB solution changes from blue to green to yellow when breath is bubbled through" (10.04.1), and "The rate of color change of BTB solution varies" (10.05.1). The development of additional propositions, each interrelated to some previous proposition(s), finally results in the development of the proposition, "BTB solution changes color from blue to green from interaction with some carbon dioxide and changes color to yellow from interaction with more carbon dioxide." Part of the desired result of this instructional segment is the development of a generalization of the nature of the interaction between BTB solution and carbon dioxide. Referring to the chemical reaction analogy, this combination and sequence of propositions resulting in the development of an important proposition, is one of the desired properties of the interaction of the component atoms resulting in a developed modecule.

Instructional Unit Characteristics

By using some of the feature of an instructional unit's component activities, important characteristics of what instruction would look like according to the literal program analysis can be illustrated. The Management feature is one of the important features in this analysis. This feature identifies the organizational structure for an activity. There are three fundamental options for classroom organization:

1) whole class,

2) small groups,

3) individual student.

For the teacher, classroom operation is fundamentally the same for either small group or individual student organizations. Activities with either of these management features are usually characterized by being student centered. These two differ from the whole class organization which is either teacher centered or a combination of teacher and student centeredness.

A classroom shift or transition occurs when the classroom management feature changes from one activity to the next. Looking at this feature for the sequence of activities in an instructional unit provides some sense of the intended "rhythm" for the unit. The first instructional unit, group 1, is composed of thirteen individual activities. Figure 4-5A illustrates the frequency of organizational transitions and their location in the instructional unit. For the first instructional unit there are four fundamental organizational transitions. The unit starts with a whole class organization, goes to an individual organization, back to whole class, back to individual, and finally back to the whole class organization.

Examination of the students' and teacher's roles indicates another source for classroom transitions. An activity involving a discussion (i.e., 10.01) identifies the teacher's role as leader and the students' role as participant. This combination of roles involves the activity centering on both the teacher

FIGURE 4-5A

CLASSROOM MANAGEMENT TRANSITIONS FOR THE GROUP 1 INSTRUCTIONAL UNIT SEGMENT 1

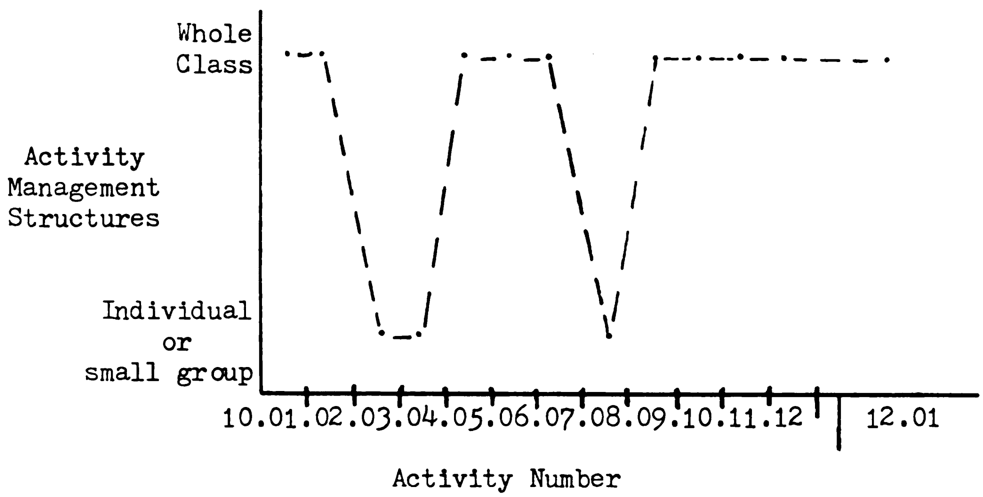
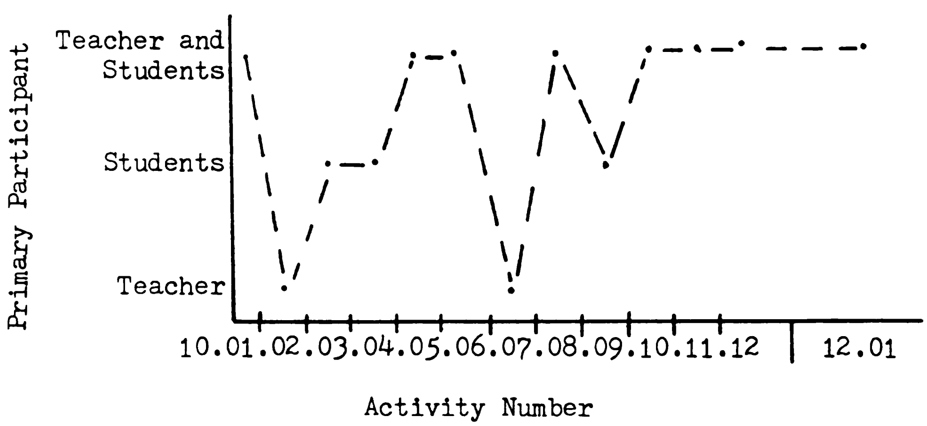


FIGURE 4-5B

CLASSROOM PARTICIPANT TRANSITIONS FOR THE GROUP 1 INSTRUCTIONAL UNIT



and students. When the activity engages the students in manipulation of equipment (i.e., 10.03), the fundamental focus of the activity centers on the student. The last variation involves centering the activity on the teacher. This occurs in two different instances: 1) when the teacher is providing instruction, and 2) when the teacher is lecturing. This shift in activity focus also results in a transition in the classroom. As shown in Figure 4-5B, considering the primary activity participant as a transition factor would result in seven possible transitions. Considering both the organizational and participant factors with respect to the classroom transitions, there are a total of seven with activities .03, .05, .09, and .10 involving both types of transitional factors.

Identifying the frequency and nature of the intended classroom transitions could be important since transitions are one of the hardest functions for a group to accomplish. In classrooms, transitions are places teachers most frequently encounter discipline problems (Yinger, 1977; Hill-Burnett, 1978). For groups frequently repeating similar transitions, routines or social customs are often established to reduce ambiguity and transitional difficulty (Yinger). The nature of instruction according to the literal program involves frequent transitions. Chapter Ten involves a total of eleven transitions in the twelve activities designated to be accomplished in one class period. This high incidence of classroom transitions would indicate a great deal of teacher attention may be required in order to establish effective classroom management procedures or routines to accomplish the large degree of transition indicated.

Conclusion: Literal Program Analysis

The purpose of the literal program analysis was to identify what instruction would be like if it were taught as described in the Teacher's Guide. Specifically, the analysis was to answer research question 1.0 of this investigation:

> 1.0 What are the activities in Part Three, the "Oxygen-Carbon Dioxide Cycle" in the SCIS program and what features are identified? (p. 17)

The preceding analysis has shown the information provided with the Teacher's Guide can be translated into an individual activity framework. This activity framework can also be analyzed according to ten catagories which identify and document nine different features for each activity. The identification of the activities by these features is referred to as the literal program approach. The results of the analysis answer a fundamental set of questions when addressing the issue of activity-based science instruction:

1. What is to be done? (task)
2. What is needed to do what is to be done? (materials)
3. Of what is to be done, what do the students do? (student role and anticipated behavior and management)
4. Of what is to be done, what does the teacher do? (teacher's role and planned behavior)
5. From what is to be done, what is to be learned? (knowledge addressed)
6. How does this fit into the SCIS learning cycle? (strategy)

The ability to relate and compare the teacher's intentions and the actual events of instruction to this framework of the literal program provides a very important resource for determining not just what occurs during activity-based science instruction, but also for identifying how what occurs relates to what the program intends. This is an important part of any effort at improving instruction. Improving suggests an evaluation and evaluation requires some standard or comparison. This research was not evaluative in the classic tradition though the need for a base or standard to compare to provided a much more useful perspective.

One of the fundamental premises of this study was that the actual program has a significant influence on the teacher. In order to determine the validity of such a premise, an understanding of the program as provided by the literal program analysis was required.

While not part of the original analysis prior to observing actual classroom instruction, the later analysis of the activities according to type or purpose seemed a useful notion. This appeared to be an additional feature of activities that was important to identify.

The analysis identified four activity types: what, how, doing, and why type activities. Further, the analysis showed that activity types were sequenced and cycled through the literal program. A cycle generally consisted of the following pattern:

1. What activity(s) identified what the main concept was that was going to be investigated.

2. How activity(s) identified an investigation and procedures the students were going to be involved in doing.

3. Doing activity(s) involved the students in actually engaging in the investigation described in the how activity.

4. Why activity(s) essentially developed the results of the doing activity and the subject matter content that was to be learned.

The identification of this feature for identifying activities and the systematic pattern of their presentation in the literal program analysis was the result of trying to make sense of what was going on during actual instruction. Adding this feature to the analysis of the literal program provided a meaningful reference for the analysis of both the teacher's intentions and of actual instruction.

In summary, the literal program analysis identified the activities as described in the program materials according to a specific set of features based on a fundamental set of classroom questions. The analysis was used as a basic part of the researcher's perspective for investigating and analyzing both the teacher's intentions for teaching and actual instruction for the portion of the program analyzed.

B) Teacher's Intentions for Instruction Analysis

This section is an analysis of the case teacher's intentions for teaching "Part Three" of the sixth grade SCIS program's Ecosystem unit. The primary functions of the analysis of the teacher's intentions are 1) to determine to what extent the teacher's intentions reflect the literal program approach, 2) to determine the nature of the teacher's modifications of the literal program, and 3) to determine what accounts for the differences between the program approach and the teacher's intended approach. The following analysis is meant to fulfill each of these functions.

Nature of the Teacher's Intentions

Prior to what Jackson (1965) refers to as "interactive" teaching, a teacher engages in "preactive" teaching. Interactive teaching has received almost exclusive research attention compared to preactive teaching. Activities included in preactive teaching are lesson planning, preparing and setting up equipment, thinking about past and future interactive teaching, and so forth. Yinger (1977) argues the rapidity and immediacy of interactive teaching dictates that much of the problem solving and decision making required for teaching takes place in the preactive phase (this argument was developed in the section Rationale for Analysis of Teacher's Intentions, p.43) While there are important interactions between preactive and interactive teaching, the above named aspects of interactive teaching and their nature can be identified and discussed.

The major component reflecting the teacher's intentions for instruction was lesson planning. During an interview, the teacher identified four basic levels of planning:

- yearly planning
- term planning
- weekly planning
- daily planning

As they were described, the four levels can be consolidated into two groups each fundamentally different from the other and suited to different purposes. Yearly and term planning attend to instructional concerns at the macro level. The macro level includes such issues as when in the daily routine will science be scheduled, where physically in the classroom will science be taught, which of the two science units will be taught first, what size groups will the students typically work in, and so forth. Weekly and daily planning were reported and observed to attend to the micro concerns of instruction: how often will science be taught this week, which activities will be done which days, what specific materials are required for each activity, and so forth.

Two of the levels, weekly and daily planning, were directly observed during this study. Information concerning term and yearly planning was obtained through teacher interview. While there are interesting and important questions about the macro level plans, this analysis focuses on the micro level components and their nature.

Weekly Lesson Plans

For this teacher, the most significant level of planning for actual instruction was in weekly lesson planning. For science, the weekly lesson planning involved the teacher planning instruction for the coming week at some time in the later part of the current week. The planning determined what activities would be done and how many days would be devoted to science during the science/social studies period. During this planning session, the teacher was also conscious of other influencing events such as parent-teacher conferences, special classes such as sex education, or other events which needed to be considered in planning the school day. Specific instructional planning for a longer period than a week was reported by the teacher as being inefficient due to the uncertainties of class schedules and of instructional progress. Modification of the plans for one week were not extensive and did not have the implications for revision which specific longer range plans would have required.

The content and nature of the weekly lesson plans was obtained by the procedures identified in the "Analysis of Teacher's Intended Approach" (page 49). The actual planning and stimulated recall of the thought process and content during planning by the teacher provided the information about the weekly lesson plans.

The actual process of planning was very consistent for the teacher. Late in the week, either Thursday or Friday after school, the teacher would sit at her desk with the SCIS Teacher's Guide and her weekly lesson plan book. This process, as it naturally occurred, was video taped. The process resulted in several directly observable outcomes. First, the 1:00 to 2:00 o'clock square designated as either science or social studies for sixth grade, contained notes relating to the intended lesson.

These notes are shown as they appeared in the plan book for "Part Three" in Figure 4-6. The nature of these notes from lesson planning are consistent with the findings of teacher lesson planning from previous studies (Morine, 1976; Smith and Sendelbach, 1978). The notes are very cryptic and specific with the primary components being 1) materials, 2) specific chapter number and title, and 3) a brief description of the activity.

Other observable products of the planning sessions were written notes and underlinings by the teacher in the <u>Teacher's Guide</u>. This book was the only reference the teacher used while lesson planning. This sole dependence on the <u>Teacher's Guide</u> provides some evidence for the notion of the curriculum program being one of the major factors influencing the teacher's intentions for instruction. The underlinings and notes added by the teacher referred to materials, timing, and procedural points for the activity.

The last activity of the planning process was the accumulation of materials for the referenced activities. These materials were obtained from a variety of storage locations in the room and were consolidated in the science teaching area near the teacher's reference table.

While the above mentioned events and products of the planning process provide significant information about the teacher's apparent intentions for instruction and her planning process, an understanding of what these plans meant to the teacher

FIGURE 4-6

DOCUMENTATION OF LESSON PLANS FROM TEACHER'S WEEKLY LESSON PLAN BOOK

Week Beginning November 13

1 hour for entire 6th Pre-test for whole group

Begin new unit
Neil--video tape #10-Breath & BTB. vinegar, ammonia, BTB, straws

#11--Where did the yellow go? BTB, vials with caps, straws, labels, dots. Observe yesterday's.

Week Beginning November 20

#11 in science text to do rest of page 16 except last one

Finish science investigation from yesterday

Week Beginning November 27

Do #12 science-Seltzer Gas and BTB - vial with hole in cap, tubing, seltzer tablet. Discuss.

Do #13--Demonstration of soda and BTB. Discuss Monday ex and today's

Discuss briefly about science

Week Beginning December 4

#14--Inventing O and CO_2 Cycle. Terms - 4 vials, labels, dots, straws, BTB-green & blue. p. 18 & 19. Record hypothesis

Record data on p. 18 & 19 after observation of data from yesterday. Record class on board.

Discuss if light or dark would effect the above. Place ½ of each of items in dark (some). Do page 20 hypothesis.

(12/4 cont'd)

Check the above in light or dark. Record p. 21. Discuss their results

Week Beginning December 11

Do #15 with plant and BTB- in light and in dark.
Discuss CO_2 - O cycle

Discuss science results from yesterday. Be sure to clarify reactions to green solution CO_2 to O.

was necessary. Many questions were still open for interpretation concerning the significance and meaning of the planning to the teacher. This investigation and analysis was accomplished by engaging the teacher in stimulated recall of the planning process by watching the video-tape recording. The information from the stimulated recall sessions provided a much richer understanding of the teacher's intentions. The total information from the whole planning session resulted in being able to identify many of the features of the teacher's problem space -- the stimuli to which the teacher responds and their intentions for action (desired goal situation).

The information from the whole planning session was reviewed and analyzed using the Plan Analysis Record Form (see Analysis of the Teacher's Intended Approach for procedure). Appendix B contains a sample of this detailed analysis.

Daily Lesson Plans

The final level of planning in the preactive phase of teaching for this teacher was daily planning. This process occurred during the whole school silent reading period, from 12:15 - 12:30. During this time the teacher reviewed the Teacher's Guide, the notes made from the weekly planning sessions and gathered or arranged specific materials for the day's lesson. For example, during a post-instructional interview (11-17-78) the teacher commented about the daily lesson planning to be done in the next class period:

> I will read this (the Teacher's Guide) again Monday morning or Monday afternoon before class to have it fresh in my mind as to what they (the students) are going to do. Also, I will review the notes I've made reminding me of the various things I should bring up in class -- such as fill to capacity with no air space and placing it in a place of their choice in light and the temperature.

Daily lesson planning, therefore, was primarily a review and preparation process.

Teacher's Intentions Compared to the Literal Program

One of the questions of this study is to determine the extent the teacher's intentions reflect the literal program approach. While the data collected from the planning sessions did not provide evidence for a portion of the activities identified from the analysis of the literal program, the evidence which was available indicates the teacher's intentions were to include the majority of those activities (26 of 50 activities: 52%)

The reason information was not available for all the activities as identified in the literal program analysis relates both to the purpose of this study and the research methods. For both the teacher's intentions and the actual instruction portions of the study, the purpose was to understand the processes as they occurred naturally. Efforts were made to produce as little research effect as possible. Therefore, probes to the teacher's intentions during instructional planning were designed to solicit as much detail of what the teacher was planning with little interference to the process. The activities represented in the literal program analysis are the result of an analysis -- they are not so identified in the Teacher's Guide. The teacher interpreted the program as it was presented in the written prose and pictures of the Teacher's Guide. The information from the Plan Analysis Record Form provided the basis for judging whether an activity was intended to be included as described in the literal program analysis, or included with modification, or excluded. Table 4-1, "Teacher's Intentions Compared to Literal Program Activities", compares the activities from the literal program approach to the teacher's intentions on the basis of this framework. Notes are provided at the bottom of Table 4-1 describing the modification to an activity, the evidence for classifying an activity as excluded, or missing information concerning some feature of an activity.

The purpose of the analysis of the teacher's intentions was to understand the nature of the intentions. Table 4-2, "Evidence for Teacher's Intentions According to Instructional Function Classification" identifies for each of the activity types in the literal program analysis whether there is evidence the teacher intended to include the activity. The rank order of activity type the teacher attended to is:

1) "doing" activities (15 of 21 or 71%).
2) "how" activities (6 of 9 or 66%),
3) "what" activities (4 of 8 or 50%),
4) "why" activities (5 of 17 or 29%).

Table 4-1

KEY

1. No mention of directing students what to look for.

2. No evidence if description will involve discussion relating to 6,7,8, 10, or 11.

3. No evidence for attention to control of variables.

4. Same as 3.

5. Only one class period scheduled for ch. 11 in original plans.

6. Evidence indicates instruction for set-up without demonstration.

7. No evidence if students experimental design will be solicited.

8. No evidence for making permanent record of data.

9. No evidence for construction of class data chart.

10. No evidence for nature or content of discussion.

11. No time provision for repeating experiments.

12. Evidence from stimulated recall after probe but not added to written plans.

13. No evidence, but will probably be done since 3 is to be done. Students must get instruction to do 3.

14. No evidence class data chart will be done.

* Revised lesson plans, two days scheduled for chapter 11

5A evidence for intending to do chapter 13 but no evidence for purpose

Table 4-1

TEACHER'S INTENTIONS COMPARED TO LITERAL PROGRAM ACTIVITIES

Evidence / Activity	Chapter 10											Chapter 11								Ch.12			Ch.13		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	1	2	3	1	2	3
Evidence for Exclusion															X 5	X 5	X 5	X 5	X 5				X		
No Evidence	X		X			X	X	X	X	X	X					* X	* X		* X			X		X	
Evidence for Inclusion: w/o apparent modification				X	X 2							X	X 3	X 4	* X						X	X	X 5	X	
w/ apparent modification		X 1																X 5A	X 6						

continued below

	Chapter 14																			Chapter 15					TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1	2	3	4	5.	
Evidence for Exclusion																X 11	X 11								5
No Evidence							X	X			X							X	X		X 13				19
Evidence for Inclusion: w/o apparent modification			X	X	X	X 8				X		X	X	X 9	X 10				X 12			X	X 13	X	23
w/ apparent modification																									3

Table 4-2

Evidence for Teacher's Intentions According to Instructional Function Classification

Activity \ Type	WHAT	HOW	DOING	WHY
10.01	0			
10.02		(+)		
10.03			0	
10.04		+	+	
10.05				(+)
10.06				0
10.07				0
10.08	0			0
10.09			0	
10.10				0
10.11				0
11.01	+			
11.02		(+)		
11.03			(+)	
11.04			+	
11.05			0	
11.06				0
11.07	(+)			
13.01		+		
13.02			+	
13.03				0
11.08			0	0
12.01	+	+		
12.02			+	
12.03				+
14.01	-			
14.02		0		
14.03			+	
14.04			+	
14.05			+	
14.06			+	
14.07				0
14.08				0

(cont'd)

Table 4-2 (cont'd)

Type / Activity	WHAT	HOW	DOING	WHY
14.10			+	
14.11				0
14.12	+			
14.13		+	+	
14.14			+	
14.15				(+)
14.16		-	-	
14.17			-	
14.18				0
14.19			+	+
15.01	0			
15.02		0		
15.03			+	
15.04			+	
15.05				+
	4 of 8 (50%)	6 of 9 (66%)	15 of 21 (71%)	5 of 17 (29%)

Key

Exclusion -

Inclusion +

No Evidence 0

( ) Indicates no evidence for a significant element of the activity

The analysis of the teacher's intentions with this framework provided some notion of the type of activities and features the teacher made explicit reference to in planning for instruction. The activities for which no evidence of intent was available also provided important information. For twenty-one activities (38%), no evidence was available indicating whether the teacher intended to include, modify, or exclude them. Examination of these activites for which no evidence was available, indicated the following order:

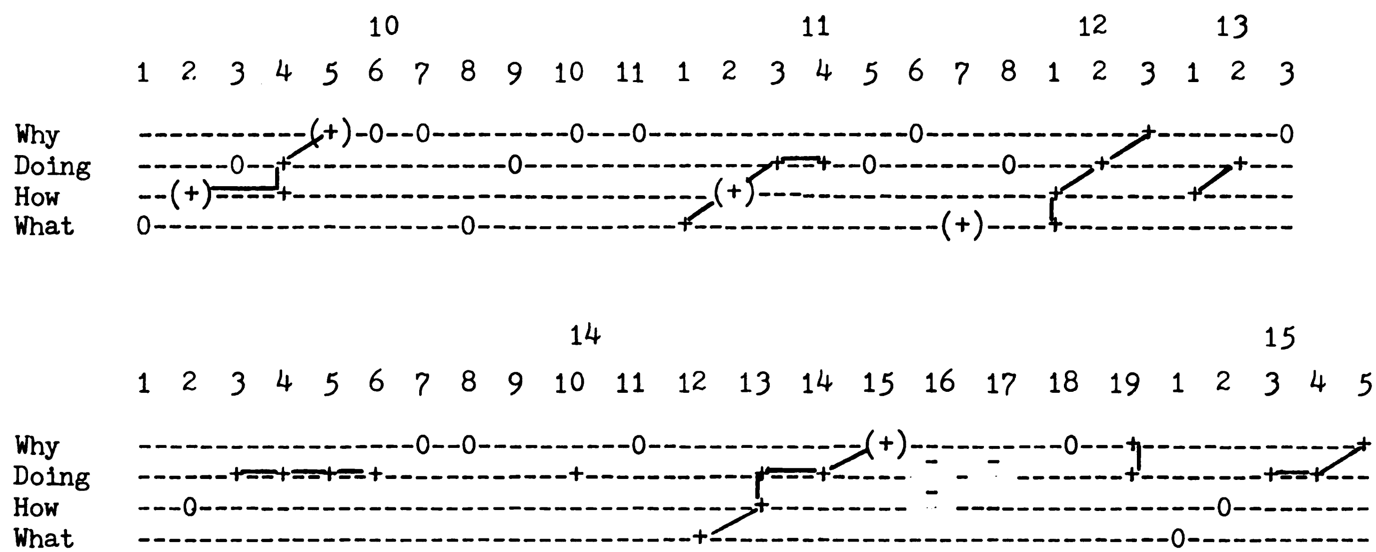
1) "why" activities, 12 of 17 (71%)
2) "what" activities, 3 of 8 (38%)
3) "how" activities, 2 of 9 (22%)
4) "doing" activities, 4 of 21 (19%)

This order is the reverse of the order the evidence indicated would be included. This information was used to develop a notion of the teacher's problem space during planning.

The inclusion, exclusion, and ranking of activity types corresponds to a problem space for the teacher that appeared to be first, concerned with determining what material manipulations the student is to be engaged in; second, how the student is to engage in the manipulation; third, what in general an activity group is about; and fourth, why specific activities are being done. In other words, the teacher appeared to be attending to certain types of activities and information relating to certain activity features. Figure 4-7 illustrates the pattern of activities as indicated from the intentions. This pattern shows instruction centering on doing type activities.

FIGURE 4-7

TEACHER'S INTENDED FUNCTION AND SEQUENCE OF LITERAL PROGRAM ACTIVITIES



Key

+ Evidence for intentions to include

- Evidence for intentions to exclude

0 No evidence

( ) Indicates no evidence for a significant element of the activity

The notion of frames or mental schema as identified by Shank and Abelson (1977) and Minsky (1975) is consistant with the above finding. Frames are an additional perspective of an information processing framework which can be used to understand the teacher's intentions and lesson planning. The particular orientation the teacher brings to the task environment will influence the problem space the teacher brings to the planning process and, therefore, the particular information sought and considered during the process. The significance of the four activity types indicated by this analysis makes sense from a classroom perspective.

Since this teacher is planning for instruction using an activity based program, the most significant issue the teacher must confront is engaging the students in activities. The notion is supported both by the high percentage of "doing" activities the teacher attended to (71%) and in the content of the written plans (see Figure 4-7, p. 105). Many of the written references involve action verbs: "do rest of", "observe yesterday's", "discuss briefly", etc.

Similar evidence indicates the second most important problem this teacher attends to is related to "how" activities -- the means and procedure problem frame. Again, the percentage of such activities (66%) and the evidence from the actual written lesson plan indicate such an orientation. Many of the references in the written plans relate to specific materials required. Notes added to the Teacher's Guide also relate to procedures for using the materials -- both characteristic features of how type activities.

Both "what" and "why" type activities are considered in a lower percentage to times (50% and 29% respectively). The written plans also contain few references to features characteristic of what and why type activities such as specific learning objectives or goals. This indicates that the teacher does not attend to either of these frames as frequently when planning for instruction.

A notable exception to the teacher's apparent orientation in lesson planning occurred toward the end of "Part Three". In chapter 15, a large percentage of the activities involve discussion of previous experimental results which are to be related to a diagram of the oxygen-carbon dioxide cycle. The need for addressing "why" activity type information -- subject matter content-- becomes more necessary. In the planning process, the teacher recognizes this need but then reports having trouble understanding some of the content with respect to this frame. During the stimulated recall of the planning session the teacher comments that, "... there are things that ought to be included in the Teacher's Guide since teachers do not have the planning time to really study these things." She further comments that she has to read the Teacher's Guide while the students are doing the activity to see what else she has to say, even if she had read it a couple of times. This additional reading during actual instruction is necessary, she says, because she doesn't really understand the subject matter (Plan Analysis Record: Stimulated Recall 12-07-78-4).

Conclusion: Analysis of Teacher's Intentions

The purpose of the analysis of the teacher's intentions is to understand the teacher's interpretation of the program and their intentions for instruction. Specifically, the analysis is to answer question 2.0 of this investigation:

> 2.0 What are a teacher's intentions for instruction of the Oxygen-Carbon Dioxide Cycle?
>
> > 2.1 How is the program approach reflected in the teacher's intended approach?
> >
> > 2.2 What is the nature of the teacher's intended modification of the program approach?
> >
> > 2.3 What accounts for the difference between the program approach and the teacher's intended approach?

The analysis of the teacher's intentions indicates that the teacher does engage the students in manipulating materials. This is an important aspect of the SCIS program approach. This aspect is reflected by the high percentage of doing type activities (71%) included in the teacher's intentions. This was anticipated by virtue of the selection criteria of the teacher for the study -- a teacher using the SCIS program who, by assessment of the District's Science Coordinator, uses the program successfully. Clearly, when one examines this teacher's lesson plans, it is obvious the teacher is teaching the SCIS program.

The teacher's intentions can be characterized as being program based. The literal program serves as the point of departure for the teacher's establishment of intentions. The investigation showed the material manipulation to be the primary influence on the teacher. The teacher focuses on these activities and the associated teaching requirements for doing them. This is reflected in the high percentage of inclusion of how and doing type activities.

Modification of the literal program approach is also evident from analysis of the teacher's intentions. In terms of activity types the teacher most frequently excluded why activities (12 of 17: 71%) -- activities which explicitly develop subject matter knowledge elements. By restricting this segment of the analysis to the intentions of the teacher as they were best able to be determined, it can not be completely assertained whether why type activities would actually be attended to during instruction or eliminated altogether. The total analysis of the study, which includes analysis of actual instruction, reflects a lack of attention to why type activities throughout the data. This will be further elaborated on in the concluding analysis.

Throughout the planning process, the teacher made reference to the difficulty of locating and interpreting the Teacher's Guide. The information processing perspective of a person's problem space and cognitive frame provides a means for accounting for this problem and the teacher's apparent modification of the literal program approach in her lesson planning. The teacher approaches the task environment of planning for instruction with different problem spaces. That is, the teacher does not approach planning for instruction in a holistic fashion but has different problem frames that are attended to individually. By nature of trying to engage the students in hands-on activities, the teacher's primary concern is in determining what materials the students used and what they are supposed to do with them. Addressing this problem of materials consumed a great portion of the limited time the teacher had available for lesson planning. The modification of the literal program by not addressing the specific subject matter to be learned by the teacher during planning was not an intentional modification. The teacher realized such subject matter material to be learned was within the program and sometimes commented on not having attended to it during a planning session. The intent, was to address such content another time. The problem, however, turns out to be that time was seldom allocated for it. Again, this analysis is supported in examination of actual instruction.

The major factors accounting for the difference between the literal program and the program as interpreted from analysis of the teacher's intentions appears to be a difference in goals for instruction. For the literal program, the goals are generalized to be student involvement in hands-on activities in order to generate experiences from which both concrete and abstract subject matter concepts can be developed and learned. For the teacher, the goal of student involvement in hands-on activities is apparent. To what extent the teacher has similar subject matter content learning goals as the literal program is uncertain. While the evidence does not indicate the specifics of such goals, there is evidence the teacher intends for learning to occur. The analysis of actual instruction provides more information relevent to understanding the differences between the literal program and the teacher's intentions. As stated previously this is the result of important interactions and interrelations between instructional planning and actual instruction.

C) Analysis of Actual Classroom Instruction

This section is an analysis of the actual instruction of "Part Three" of the sixth grade SCIS program's Ecosystem unit. The primary functions of the analysis of actual instruction are: 1) to determine what actually occurred in the teaching-learning process in the classroom during instruction of "Part Three" and to account for these occurrances; 2) to determine the extent actual classroom instruction reflects the teacher's intended approach and the literal program approach; and 3) to determine what accounts for the differences between the teacher's intended approach and actual classroom instruction. This analysis will make use of all available information from the study to address each of these functions.

The analysis of actual instruction is presented in two parts. The first part analyzes actual instruction as compared to the analyses of the literal program and the teacher's intentions. Part one, therefore addresses important aspects of all three research questions using the rich and detailed perspective already presented. Some very important aspects of what actually occurred in the classroom, however, are not adequately reflected with this perspective. Part two of this section will provide the context for the analyses of part one. Part two moves away from the comparative analysis to a more descriptive analysis. Understanding the context of actual instruction provides important information in order to account for the analysis of actual instruction from part one of this section.

PART ONE

Actual Instructional Activities

This study hypothesized that one determinant of actual instruction is the teacher's intentions. These intentions have been examined by way of the teacher's lesson plans for actual instruction. One of the conclusions from the analysis of the teacher's intentions is that the activities from the literal program which involve material manipulation by the students are the primary focus of the teacher. Clear evidence was available that the teacher attended to materials required for the students and how the materials were to be manipulated by the students. The analysis of the teacher's intentions, however, was unable to determine whether or not the teacher considered and/or attended to the subject matter content of the literal program's activities. For many activities there was no evidence indicating whether the activity or some significant portion of a feature was going to be included or excluded.

The available evidence indicated the teacher had a hierarchy of concerns with respect to planning for instruction.

The results of the analysis of the teacher's intentions suggests the pattern of inclusion, modification, and exclusion of activities from the literal program may be useful in gaining an initial understanding of this case study teacher's instruction. Table 4-3 compares the activities included in actual instruction to the activities of the literal program. Table 4-4 identifies the activities by type and their inclusion, modification or exclusion. The patterns and their significance in understanding aspects of what occurred in the actual instructional process will be the major focus of the following sections.

Teacher's Frame and Actual Instruction

Several important characteristics are evident from examination of actual instructional activities (Tables 4-3 and 4-4). First, the rank proportion of activities included in instruction unmodified from the literal program, are 1) "doing" activities (15 of 21, 71%); 2) "how" activities (5 of 10, 50%); 3) "why" activities (3 of 16, 18%); and 4) "what" activities (1 of 7, 14%). Again, as was the case with the teacher's intentions, doing and how type activities are the activities most often included and why and what type activities are least often included. This consistency of orientation by the teacher in both planning for instruction and in actual instruction supports the hypothesis that the teacher is primarily concerned with engaging students in the manipulation of materials; how and doing type activities.

Table 4-3

Activities of Actual Instruction Compared to Literal Program Activities

Activity/ Evidence	111478 10: 1	2	3	4	5	6	7	8	9	10	11	111578 112078 112178 11: 1	2	3	4	5	6	7	8	112778 12: 1	2	3	13: 1	2	3
Excluded			X				X	X	X		X					X	X	X	X						
Included . without significant modification		X		X	X							A X			X						X	7A			
. with significant modification	1 X									2 X			5 X	5A X						6 X		7 X	8 X	9 X	10 X

Activity/ Evidence	120478 120578 120678 120778 14: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	121178 15: 1	2	3	4	5
Excluded					13 X			15 X			16 X				18 X									
Included . without significant modification			X	13 X	X	X			X	X			X	X		19 X		21 X	X		X	X	X	
. with significant modification	11 X	12 X					14 X					17 X					20 X			22 X				23 X

Table 4-3

KEY

1. Introduction only referred to new activities which do not involve the aquarium/terrariums. No mention of investigating exchange of gases.
2. Students are told differences in color due to "variables" but nothing more is involved; better development in second class.

5A. Modification involves teacher's identification of different places to put vials without development of concept's variables; experimental control.

4. No list of potential causes for change in BTB solution is made on board -- only verbal after recording in S.M..
5. Variable & control are confused as all students use two vials, 1 with lid & 1 without as well as placing in different locations.
6. Teacher assembles a gas generator but does not operate generator to obtain confirmation students observe dissolving tablet or testing to determine what bubbles are; they are told.
7. Teacher identifies color change students have seen; does not ask what evidence is for identified gas. No comparison to results from blowing into BTB solution. Almost exclusive attention to classrm. & mater. mgmt.

7A. Better development in second class.

8. Teacher describes experiment instead of asking for student design.
9. BTB solution is not added to soda bottle & tube not in BTB solution; students are not asked if they see bubbles or which way"gas"is moving.
10. Brain teaser is assigned but teacher does not circulte & assist students or judge how they relate to the experiment by their responses.
11. Ecosystem chart is not used & concept of student statements representing a theory of how plants & animals interact with O_2&CO_2isn't mentioned.
12. Students are told they will be experimenting to determine whether plants & animals produce or use CO_2.
13. The first class does not do the predictions of experiment results. Second class instructed to do top half but teacher doesn't check.
14. Discussion only involved reporting of color change observed. Teacher tells students this demonstrates organisms give off CO_2 & plants O_2.
15. Key activity! This activity introduces the O_2 - CO_2 cycle.
16. Brain teaser is not reviewed, therefore, proposition that terrestial animals produce CO_2 is not discussed.
17. Tells them the experiment is to determine there is a difference in results if light or dark.
18. No real discussion other than the observed results (color comparison).
19. Repeat of same experiment with Anacharis in light to see if can get green BTB to turn blue. Not repeated in dark.
20. Discussion of proposition that plants produce O_2 (in light).
21. Discussion of experimental results to date begins 121178. Discussion starts to develop notion of the O_2-CO_2 cycle; reviewed again 121278.
22. Students do not hypothesize whether land plants are the same as water plants but are told that is what they will investigate.
23. Discussion of results focuses on development of O_2-CO_2 cycle & not the "discovery" that the relationship is constant for land & aquatic plants.

Table 4-4

Inclusion, Modification, or Exclusion of Activities in Actual Instruction According to Activity Function Classification

Activity	WHAT	HOW	DOING	WHY
10.01	M			
10.02		X		
10.03			E	
10.04		X	X	
10.05				X
10.06				
10.07				E
10.08	E			E
10.09 (Optional)			E	
10.10				M
10.11				E
11.01	X			
11.02		M		
11.03				M
11.04			X	
11.05			E	
11.06				E
11.07	E			
11.08 (Optional repeat)			E	E
12.01	M	M		
12.02			X	
12.03				M
13.01		M		
13.02			M	
13.03				M
14.01	M			
14.02		M		
14.03			X	
14.04			X	
14.05			X,E	
14.06			X	
14.07				M
14.08				E

(cont'd)

Table 4-4 (cont'd)

Activity	WHAT	HOW	DOING	WHY
14.09 (Cleanup)			X	
14.10			X	
14.11				E
14.12	M			
14.13		X	X	
14.14			X	
14.15				E
14.16		X	X	
14.17			X	
14.18				X
14.19			X	X
15.01	M			
15.02		X		
15.03			X	
15.04			X	
15.05				M
TOTALS	8	9	21	17
+ = 24 M = 17 E = 15	+ = 1 M = 5 E = 2	+ = 5 M = 4 E = 0	+ = 15 M = 2 E = 5	+ = 3 M = 6 E = 8

The proposed explanation of the teacher's frame according to activity types included, modified, or excluded requires some analysis of activities inconsistent with the explanation. Of the thirty-seven how and doing type activities, only five of them were excluded from actual instruction. The nature of these five activities accounts for their exclusions from the anticipated pattern.

Activity 10.03 is the first activity of the how and doing type excluded. Examination of the activity, however, reveals that it is nonessential to the material manipulations involved by the students. The activity is essentially one of orienting student thinking about the events they are observing. The literal text states:

> When the children see a color change from blue to green, ask if the solution will continue to change color or what will happen if they continue to blow. Will the solution turn a different color if it is stirred while they are exhaling into it?

The students are already involved with the materials and activity 10.03 only suggests they try stirring the BTB solution while blowing bubbles through it. The same characteristic is true for activity 11.05 -- which is also excluded -- it is oriented toward directing student exploration and explanation of the events of the activities they are doing. The exclusion of these two activities, therefore, does not appear to be inconsistent with the teacher's orientation of including how and doing activities.

Activities 10.09 and 11.08 are also doing activities excluded from actual instruction. Both activities are optional in nature as identified by the literal text. Activity 10.09 states, "If the children wish to try the experiment..." and activity 11.08 states, "... some children may wish to repeat their experiments...". The exclusion of these two activities, again, is not a contradiction of the teacher orientation toward <u>how</u> and <u>doing</u> activities. In fact, their exclusion is consistent with the lack of attention by the teacher to the <u>what</u> and <u>why</u> activities. Activity 10.09 follows from the results of discussion in activity 10.08 -- a combination what and why activity -- which is also excluded. Similarly, activity 11.08 results from the discussion on activity 11.06, a <u>why</u> type activity which is excluded from actual instruction. The two excluded activities are significant only when the subject matter content of the activities is attended to -- characteristics of <u>what</u> and <u>why</u> type activities.

For each of these four activities, the analysis of the teacher's intentions provided no evidence indicating whether they were to be included or excluded. Since they were excluded from actual instruction, it may be that they were not part of what the teacher saw as important from the literal program. This could answer, to some degree, the question of whether the teacher was attending to the subject matter content during planning, but that the procedures for the investigation were not sensitive enough to measure such concern. The most likely explanation is that the subject matter content of the activities is of low importance for the teacher since the same orientation essentially excluding subject matter content is also evident in actual instruction.

The discovery and interpretation of this pattern of activity inclusion, modification, and exclusion is consistent with comments made by the teacher. During one post-instructional interview (Nov. 17, after completing Chapter 10), some of the possible basis for Ms. W's orientation is revealed. We were talking about the activities of Chapter 10 and relating to beginning Chapter 11. Ms. W commented:

> I do not want to discuss too much about it because I am (would be) giving them answers, and I want them to think about it. I think that if I tell them they will not put the work into it.

Such comments, which are repeated during other discussions, provided some basis for understanding the background for the teacher's orientation. She wants the students to figure out what subject matter content is to be learned from doing the investigations. She, therefore, sees her most important role as having the students do the investigations.

Again, this is not a case where the teacher does not consider learning as important, but rather where the teacher wants the students to "think" about the investigations they are doing and discover what is to be learned. To some extent, this accounts for the teacher's primary focus of attention being the "how" and "doing" type activities. As a consequence of this orientation however, the teacher is not always aware of the potential subject matter content knowledge the investigations address. In commenting about some of the results of students' investigations and their questions, she states:

> I guess I was not quite prepared to go into this (a discussion of an investigation's results) myself. Probably I was not as well prepared as I should have been, but that's the way some days go. I have not really thought this part out that clearly myself, I have not really had a chance to reflect on it. I am still sort of not clear on it today. Probably more following instructions than thinking of all these things. (from post-instructional interview Nov. 17)

This comment reflects the significance of the different aspects of the teaching-learning process for the teacher. She first concentrates on the requirements for doing the investigations and then, if there is time, on the subject matter content addressed.

The increased support for the explanation and understanding of the teacher's reference frames from the analysis of actual instruction is further supported by additional examination of the analyzed teacher's intended approach compared to actual instruction.

Teacher's Intended Activity Analysis Compared to Actual Instruction

Table 4-5 compares the analysis of the teacher's intended activities and the activities from actual instruction. Of the twenty (20) activities analyzed as intended to be included, fourteen (14 of 20; 70%) were actually included in instruction with no significant modification; six (6 of 20; 30%) were included with significant modifications; and none were excluded from actual instruction. This comparison indicates that the teacher's intentions to a large degree reflect the activities to be included. Similarly, as shown in table 4-5, when there

Table 4-5

Relationship Between Activities of the Teacher's Intentions and the Activities of Actual Instruction*

Intentions / actual instruction	Included w/o Significant Modification	Included w/ Significant Modification	Excluded
20 Activities +: evidence for inclusion	14 (70%)	6 (30%)	0 (0%)
6 Activities (+): evidence for inclusion, but with evidence missing for some significant element of the activity	2 (33%)	1 (17%)	2 (33%)
3 Activities -: evidence for exclusion	1 (33%)	2 (67%)	0 (0%)
21 Activities 0: no evidence	2 (9.5%)	7 (33%)	11 (52%)

*Note: The data for this table are derived from Table 4-2 and Table 4-4.

was no evidence for an activity from the analysis of the teacher's intentions, the activity was usually not included in actual instruction (11 of 21) or included with significant modification (8 of 21).

This comparison of the analyses of activities from the teacher's intentions and actual instruction indicates the procedures for the investigation of the teacher's intentions reflect what activities will be included, modified, and excluded.

Potential Subject Matter Content

As stated previously, the teacher does consider learning important and realized there is some subject matter content to be learned from "Part Three". The literal program analysis identified the knowledge addressed by the activities and showed a hierarchial development of the propositional knowledge. Furthermore, the nature of the potential subject matter content addressed by the activities through "Part Three" becomes more complex. For example, the activities in the first part of chapter ten simply develop the concept that BTB solution changes from blue to green to yellow in the presence of carbon dioxide. Later, in chapter fourteen, activities develop the concepts that animals produce carbon dioxide in the presence of either light or dark, while plants produce carbon dioxide only in the dark. The development of these concepts is dependent on understanding the concept developed in chapter ten concerning

BTB solution and carbon dioxide. The results the students are directed to actually observe from the activities in chapter fourteen related to whether BTB solution changed color. Even in the Student Manual, the students were directed to record results which related to the color of BTB solution. The development of the higher propositions is typically done in why type activities through discussion. The consequence of this was that the later activities in "Part Three" were done in a fashion that only or primarily addressed propositional knowledge elements at the lower end of the knowledge hierarchy.

The results from this study show the teacher is concerned to some degree that learning occurs, but is usually oriented to the propositions at the lower end of the knowledge hierarchy. Since the results of the activities can be addressed to the lower order propositions, the teacher can do this believing that learning is being addressed. In fact, this phenomenon accounts for some of the modifications of both the literal program and of the analyzed teacher's intentions.

Modifications Related to Potential Subject Matter Content

An analysis of the subject matter content component from actual instruction indicates learning was being addressed by the teacher but with modification from the literal program approach. Sometimes this modification related to the exclusion of specific subject matter content and sometimes to the degree of its development.

The actual instruction from chapter ten, "Breath and BTB" provides examples of both types of modifications. Activity 10.07 presents the propositional knowledge that carbon dioxide makes an acid in water and that BTB indicates the presence of this acid. (Propositional knowledge element 10.07.4) This activity is excluded from actual instruction and, therefore, this knowledge proposition is also.

In contrast to the total exclusion of a proposition, some propositions are included but not developed. Activity 10.10 presents the propositional knowledge element that variables, (such as the amount of breath exhaled, varying the amount of time breath is exhaled, and differing shades of blue BTB solution at the start) may cause differences in the rate of BTB solution color change (10.10). Activity 10.10 was done, but the nature of addressing this knowledge proposition was significantly modified. Instead of developing the difference in results the students may have perceived in previous activities, the teacher told the students any differences in colors were due to "variables". No refernces were made to actual differences in results, nor to what some of the possible variables may have been. This one reference to variables was the extent of the development of knowledge proposition 10.10.1. This modification seems to be important in terms of the associated activities of the students and the teacher. The procedure the teacher used resulted in the students hearing the proposition but not relating it to what they were doing. The concept of a variable was not developed, only mentioned.

The same sort of modification as from activity 10.10 and proposition 10.10.1 was repeated in activity 10.11 for proposition 10.11.1. Evaluation of actual instruction indicates both the activity and the proposition were modified significantly. The activity is designed to build on the discussion of variables from activity 10.10 and to determine how controlled experiments might be done in order to test each variable (propositional knowledge element 10.11.1). As in activity 10.10, the teacher did not involve the students in a discussion of controlled experiments, but instead, told the students different "variables" may have caused the different color changes. The class session ended with the students having "done" the activities from the literal program involving material manipulation. The difference is associated with the level of attention and student involvement with the matter of why they were doing what they were doing.

This same modification was carried through into the next day's lesson. This lesson (11-15-78: activities 11.01 and 11.02) involves further development of controlled experiments and variables. The activities were done but with modifications related to the development of the knowledge proposition. For activity 11.01, the discussion of possible causes for the observed result of the BTB solution changing from yellow back to blue overnight occurred after the students recorded their hypotheses in the Student Manual. This is a modification from the literal program and appears to be a consequence of the events of actual instruction and the teachers orientation. The actual events the day activity 11.01 was taught, illustrate the way such modifications occur and how they may be accounted for. The following account is from the day's field notes (11-15-78).

> The introduction to the period's lesson occurs as normal with the students seated at their desks and Ms. W at her desk. Ms. W addresses the students:
>
> > "Um, today we're going to be observing what we did yesterday--talking briefly about it, um, then we will be working also on things in your book (inaudible). Quietly move to your table."

This introduction does not indicate the teacher will be modifying the activity as eventually happened. There appeared to be the intent of first discussing the investigation's results and then reporting in the Student Manual.

> There is considerable enthusiasm shown by the students for the science activities. Some students are talking about the change in color of the BTB solution and others ask whether they will be blowing into the solution again today. Ms. W continues:
>
> > "All right, we have Denise who was not here, I think the only one, ah. We will get out a cup so she can try it out so she has an idea of what we're talking about."
>
> Ms. W obtains a cup and other materials for Denise.
>
> > "It won't take long. While the others are getting their equipment, uh, she'll be able to test this. O.K., quiet down. Denise, you're going to be blowing that - carefully so that you don't blow it all over. Just blow into it and continue to observe what is happening; anything happen. O.K., I'm going to ask the ones to get their books."
>
> Denise is given all the necessary materials and starts blowing as a student from each table obtains the books. During this time everyone watches Denise to see what happens (even though they already know from yesterday's activity). Ms. W starts,

"Now the next thing I want you to do..."

She stops as all the students are watching Denise (about a 45 second span where everyone watches Denise blow bubbles through the blue BTB).

Ms. W: "Anything happen Denise?"

Students: "First green then yellow...first dark green."

Ms. W: "Then it turned yellow?"

Denise: "Yes"

Ms. W: "O.K., why don't you just put it aside now"...

"I'm going to ask the people from table one now if you will come up here (they begin to move) - one at a time - getting your - Brad yours first, Mark, Sipio, Katie (Ms. W stands by the table in front of 'A' and calls the name of the next person's vial as they are arranged).

The rest of the class' vials are distributed in the same fashion. The students look at their vials during this process -- very little talking.

Ms. W: "O.K., now, what has happened to these?"

In unison: "Blue, more clear, turned blue"

Ms. W is at 'A' looking at the Teacher's Guide and responds:

"O.K. you do have on page 16, do the first two parts there, it says, 'What changes did you observe in the BTB solution after it stood overnight?' (read from Teacher's Guide) 'What might have caused this to happen?' That's all you have to do now. So write down your observations (fade) then we will talk about it."

The discussion prior to the students recording their results and hypotheses in the Student Manual consisted of a single reporting of the observed color change. There seemed no need for exploring this further since there was so much student discussion while Denise was doing the investigation. The lack of additional discussion may be due to the teacher referring back to the Teacher's Guide. Involving Denise in the previous day's investigation appeared to disorient the teacher as to the current day's planned activities. She referred back to the Teacher's Guide and read the assignment the students were to complete. This asked that the students write a response to the questions. The teacher directed the students to write their answers to the questions and, in a fading voice, said they will talk about them after.

This sequence of events and the elimination of any discussion of possible causes for the observed results appears to be a result of the teacher focusing on what the students actually needed to do during the class period. The procedure of discussing possible causes for the observed result is mentioned in the prose of the Teacher's Guide. The questions for the students to answer are shown in a dark outlined reproduction of the Student Manual. The teacher refers to the guide to reorient what needs to be done. The inability to read closely while the students wait for direction, resulted in the teacher directing them to write their responses to the questions. There appeared to be recall that some discussion should occur since the teacher remarked they will discuss their responses after they are recorded. The following notes record the rest of the science period:

The class is very quiet while they write in their workbooks.

Mike: "Are we supposed to draw the experiment here?"

Ms. W: "No, Mike, I said what to do didn't I? What did I tell you?"

Mike: "Do the top two".

Pause while students work.

Ms. W: "Only the top two questions! Nothing below -- nothing to do below remember. Read the instructions please."

to Denise
"You can see what happened overnight by looking at theirs."

Class is silent while the students write their answers. Ms. W looks at the T.G..

Ms. W: "O.K., has everybody had a chance to write their comments? Some of the things we talked about yesterday...we gave... does anybody remember what this is?" (writes CO_2 on board)

Student: "Carbon dioxide.

Ms. W: "Carbon dioxide. This is a shorter way of writing it. I don't think in this class we talked about variables. Ah, variables are things that are changes. Various changes; some of you, ah, your solution might look darker than others (fade) and these are kinds of things that are variables that we, ah, nothing work with, but, um, let's go on and see the major changes. Are there any questions about what may have happened.... or what happened last night?"

Student: "It changed back to blue."

Ms.W: "It changed back to blue. Yes? (to student raising hand)

Mike: "Carbon dioxide might have come out, maybe oxygen."

Ms. W: "Carbon dioxide could come out. Any other comments?"

Student: "Something drowned in it (inaudible)

Ms. W: "What may have?"

Student: "It might not have enough air."

Student: "Maybe our air was warmer as we blew in it."

Ms. W: "Temperature might have made a difference? Is that what you're saying? Anything else that may have effected it?"

Student: "All the carbon dioxide went out."(pause)

Ms. W: "Does it evaporate? Any other comments? (pause) O.K. All right, we'll think about these things and next Monday we're going to do another one -- a little different type of experiment -- by putting it in different places; possibly and so on, and watching what happens. Any questions about this?"

No student questions, so Ms. W begins to give instructions for cleanup.

The focus on the discussion was still on the observed result -- that the BTB solution turned from yellow back to blue. The discussion about their hypotheses for this change was not developed nor related to the idea of variables. That the students do record something in their books seemed to be the important part, not what they recorded. The evidence for this statement is supported in the actual events of instruction. The student hypothese were only verbalized, not recorded on the chalkboard as the literal program suggests. While this modification alone may seem insignificant, in combination with the rest of the classroom procedures and the detail given to classroom and material management, the total sum of events begins to confirm the relative low importance hypothesized for the teacher's concern for the subject matter knowledge addressed frame.

The activities at the end of chapter eleven (activities 11.05, 11.06, 11.07, and 11.08) are all excluded from actual instruction. The exclusion of these activities followed the same pattern as from chapter ten. Activity 11.04 involves the students recording the results of their experiments from the previous day. For actual instruction, chapter eleven ended with the completion of activity 11.04; activities 11.05, 11.06 11.07 and 11.08 were excluded. Activity 11.05 involves grouping the student's results for the purpose of discussion -- activity 11.06. The exclusion of both 11.05 and 11.06 is consistent. Since there was no discussion of the results (11.06), there was no purpose to checking hypotheses which were to be developed in activities 11.07 and 11.08. Again, the modification was not one of excluding subject matter content knowledge addressed, but of omitting the development of the knowledge propositions. The students did the activities which produced the results. The potential for addressing the propositions was available, but the propositions were left -- on the whole -- to be inferred by the students and not developed in class discussion. The teacher appeared occupied with the immediate requirements of involving the students in doing the investigation and recording in their Student Manuals. Accomplishing the investigation was the first requirement.

The actual instruction from chapter twelve also involved a modification related to the development of potential subject matter content knowledge. For activity 12.01 the teacher is supposed to set-up and demonstrate a seltzer tablet gas generator. The purpose of the demonstration is to have the students observe the presence of bubbles and suggest using BTB solution to determine if the gas contains carbon dioxide. The students then do activity 12.02 to make this determination. Actual instruction of activity 12.01 did not involve a demonstration of the production of bubbles, however, but involved very detailed instruction for and a demonstration of the assembly of the gas generator including the use of BTB solution. The focus of attention is changed from the observation of the production of bubbles and suggesting a means of testing to determine if they contain carbon dioxide, to the procedures for assemblying the gas generator and the identification of BTB solution used to identify carbon dioxide. Attention to the subject matter content knowledge in the activity involved only the following exchange:

> Ms. W: "I'm sure you all know what we're going to be testing for. What are we going to be testing for?"
>
> Students: "The blue in the vial. Carbon dioxide."
>
> Ms. W: "O.K. Where are we going to put the BTB?"
>
> Student: "In the big cup."
>
> Ms. W: "In the big cup. What are we going to test for then?"

Student: "If the (inaudible) transferred blue (inaudible)."

Ms. W: "Uh, there are too many people talking. I can only hear one or listen to one. Darrell."

Darrell: "Carbon dioxide will come from the vial."

Ms. W: "O.K. To see if there is carbon dioxide in here? (holds up vial) Yeh, that's right, that is what you're going to be testing for. (continues with instructions for doing activity 12.02)

The response of testing for carbon dioxide seemed to satisfy what the purpose of the activity was. While this type of modification of an activityprimarily related to the strategy involved in instruction, there was also modification related to the development of the potential knowledge to be addressed in the lesson.

Finally, actual instruction of activity 12.03 resulted in significant modification of potential knowledge addressed as compared to the literal program. Here again, the modification was one of orientation and emphasis. The literal program involves a discussion where the students are to identify the bubbles and support their answers with evidence from the results of activity 12.02. Furthermore, the discussion is to involve a comparison of the results of blowing through blue BTB solution and those of activity 12.02. In actual instruction, the discussion for activity 12.03 consisted of the following:

Ms. W: "O.K. If you've had yours work now, your solution has turned yellow. You know there is the presence of what?"

Several Students: "Carbon dioxide."

This is the fundamental propostion to be addressed -- that the blue BTB changing to yellow indicates the presence of carbon dioxide -- but this was certainly not developed through discussion, related to previous activities, nor emphasized. The accomplishment of completing the investigation -- having the gas generators operate -- and producing results that address a fundamental proposition appeared to satisfy the teacher's expectations for the lesson. After this response the teacher provided instructions for cleanup.

The investigations of chapter 12 were completed, the students engaged in the manipulation of materials, and appropriate experimental results were obtained. The same potential subject matter knowledge was available in both the literal program and in actual instruction. The actual instruction was modified to exclude explicit and direct development of much of the potential knowledge.

Chapter thirteen, "Soda Water and BTB" is an optional set of activities to use if students incorrectly insist the uncapped yellow BTB solution from chapter eleven, turned blue due to oxygen entering the solution. The activities from which such a misconseption could be discovered are 11.05 through 11.08. These activities were excluded from actual instruction. The teacher's purpose for doing chapter thirteen appeared to be to further develop the proposition that blue BTB solution turns yellow in the presence of carbon dioxide (a reitteration of the same proposition developed from the activities of chapters ten, eleven, and twelve).

The actual modification of the activities in chapter thirteen resulted in a reduction of the potential knowledge addressed by the activities. In the literal program, blue BTB solution is added to soda water to indicate the presence of carbon dioxide (activity 13.02). In activity 13.05, the soda changes back toward blue indicating the carbon dioxide is no longer present. The significant modification during actual instruction was the exclusion of adding BTB solution to the soda water. BTB solution was used to indicate that the gas going from the soda water was carbon dioxide. However, it was not used in the soda water, only in a cup. Since no BTB was added to the soda water, there was not opportunity to observe the color change from yellow to blue. Therefore, the potential subject matter knowledge to be addressed by the activities in chapter thirteen was reduced.

A discussion during the instruction of chapter thirteen also indicated the orientation of the teacher toward addressing only the proposition that Blue BTB soution turns yellow in the presence of carbon dioxide. After moving to the science tables the following discussion ensued:

Ms. W: "O.K. Just to review a bit some of the things we have done over the past few days. You have been using the solution BTB and you have been trying all sorts of different things with it. What are some of the things we've been doing with it? Vickie?"

Vickie: "We put it in the vials and breathed through it. Then we did it again and put it in different places -- some of us put it back there, some over there -- (inaudible). Then we used it with alka seltzer and it turned another color..."

Ms.W: "Did it turn different kinds of colors or did it turn kind of the same reaction each time?"

Marcus: "Yesterday it turned kind of an orange."

Ms. W: "(inaudible)... how did it change before?"

Students: "Turned green first."

Ms. W: "O.K. Um, so those were the experiments. What were we trying to find out? What was the purpose of this? Lynn?"

Lynn: "To find out if there was carbon dioxide in the air."

Ms. W: "In which air? In the room air or..."

Lynn: "In the air we blew into it. In the air we exhale."

Ms. W: "The air exhaled. That's the air blowing in there. All right. Vickie said you put the things away for a day and some changed and others did not. How did that happen?"

Student: "One was covered and one was not."

Ms. W: "That is very important point to make isn't it? Whether it is covered or not covered. O.K., today I'm going to see if I can try another experiment with BTB solution and uh, we will try it with this." (holds up ginger ale bottle) -- Long pause while the teacher arranges materials -- the students talk about the ginger ale -- and then the assembly of the materials begins. (from field notes 11-28-78)

This discussion explicitly illustrates two important points concerning potential subject matter to be addressed in instruction. First, the focus of the discussion, in terms of propositional knowledge, relates only to the color change of BTB solution in the presence of carbon dioxide and that the reaction is consistent in change from blue to green to yellow. The point was made that this change was what the day's investigation was about. Second, the results of the reaction from chapter eleven were pointed out -- (part of the basis of the interrelation of propositional knowledge for chapter thirteen). The focus in instruction, however, was that one vial was capped and one was not. There was no development of that significance. The point made was one of a procedural difference, not of its meaning.

When the results were viewed the next day, (for chapter thirteen) the discussion was very brief and only involved the observation that BTB solution in the cup turned yellow indicating the bubbles must have contained carbon dioxide. The discussion ended quickly with the teacher concluding that they had done "four experiments that show the same thing" -- that blue BTB changes to yellow in the presence of carbon dioxide. For chapter thirteen, the actual instruction involved a significant modification of potential subject matter. The modification was consistent with the modification from chapter eleven.

Chapter fourteen of actual instruction also involved modification related to potential subject matter knowledge addressed. Whereas the literal program begins the chapter with a discussion centered around the Ecosystem chart which was prepared in chapter three, actual instruction involved only the listing that people breath in oxygen and plants give off oxygen (activity 14.01). There was no explicit mention of this being an interaction or of this being part of the concept "ecosystem". Furthermore, there was no notion of the two propositions representing a "theory", only that they would be experimenting to determine whether plants and animals produce or use carbon dioxide. Finally, there was no mention that there is no test for determining whether oxygen is used or produced. (activity 14.02) The modifications of potential knowledge to be addressed excluded the relationship between the investigation and previous investigations and their corresponding subject matter content. The manipulation of the materials by the students (activities 14.03, 14.04, and 14.05) and doing the experiment were included in actual instruction.

Chapter fourteen of the literal program is directed toward the "investigation" of the oxygen-carbon dioxide cycle. The second day of instruction involves the interpretation of the previous day's experiment's results and diagraming the relationship between plants, animals, carbon dioxide, and oxygen (activities 14.06, 14.07, and 14.08). Actual instruction involved examining the previous day's experimental results -- the color change in the BTB solution-- but excluded any discussion beyond the color change. The presentation of the oxygen-carbon dioxide plant-animal cycle diagram and concept is excluded.

The third day of chapter fourteen of the literal program involves elaboration of the organism - carbon dioxide - oxygen relationship by introducing light as a variable (activities 14.12 and 14.13). Actual instruction did not involve modification of potential knowledge addressed, only the degree of attention.

The brain teaser the students did the previous day -- which is to extend the proposition that animals produce carbon dioxide to explicitly include terrestrial animals -- was not reviewed and, therefore, left the proposition at whatever level doing it had produced in the students. The discussion of the day's activities consisted of the teacher stating they would investigate the difference between the experiments which were in the light and those in the dark. The potential knowledge to be addressed was the same. The phenomena from which the subject matter content knowledge is derived were done by the students. Compared to the literal program, the development of the potential knowledge in actual instruction was more implicit and left for the students to interpret.

The fourth day for chapter fourteen and the investigation of the organism-oxygen-carbon dioxide cycle involves the addition of the effects of light in the literal program approach. This is done through a review of the previous day's activities results (activity 14.14) and a discussion (activity 14.15). The literal program includes the suggestion that activity 14.13 -- the actual experiment -- be repeated to answer any student doubts about light being an important variable (activity 14.16). Again, actual instruction involved modification relating to the development of the potential knowledge. The data were recorded (activity 14.15), but the teacher recorded the students' results incorrectly. The BTB solution with the Anacharis in the dark was recorded as changing from green to blue. The actual results (color change) of the experiment were difficult to perceive. In order to support the proposition that plants produce carbon dioxide in the dark, the teacher encouraged an interpretation contradictory to what is desirable. The interpretation of the results as the teacher recorded them indicated that plants always produce oxygen instead of oxygen production being dependent on whether light is present.

The after school discussion of the day's activity with the teacher revealed she did not understand all of the knowledge addressed by the activities. In fact, she did not realize light was a significant variable for oxygen production in plants. She therefore, was orienting the students toward experimental results which would indicate plant production of oxygen in both light and dark conditions. This misconception resulted from poor printing in the <u>Teacher's Guide</u>. Page seventy-four of the <u>Teacher's Guide</u> contains an illustration of the oxygen-carbon dioxide cycle including reference to light and dark. The arrow indicating plants use oxygen in the dark is unclear. The teacher indicated she thought it looked like a printing error and had been "erased". This unclear printing plus the teacher's lack of subject matter knowledge relating to this topic resulted in the teacher modifying the potential knowledge addressed in the discussion of the experiment. Activity 14.18 which is the inclusion of the light/dark variable in the oxygen-carbon dioxide cycle diagram was excluded at this point of instruction. The brain teaser (activity 14.19) was assigned for the students to complete. This caused gread confusion for the students, however, since the problems involve application of the plant-light---dark-oxygen-carbon dioxide relationship.

The effect of the teacher not realizing all of the potential subject matter to be addressed was that the students did do activity 14.16 -- a repeat of the experiment -- but did it to obtain better reactions of the BTB solution and plants left near the light. The next day was Friday and no science was scheduled, though time was taken to note the color change of BTB in the vials with Anacharis by the light, confirming that plants produce oxygen in the light.

During a post-instructional interview and while planning for chapter fifteen, the discussion between the teacher and myself resulted in her understanding the oxygen-carbon dioxide cycle as presented by the literal program. She knew there was more subject matter content to be addressed than had been during instruction to that point, but had not been able to determine what it was from the <u>Teacher's Guide</u>. This discussion was initiated by the teacher, as this study was not designed to be an intervention. The struggle with the subject matter was an uncomfortable session for the teacher.

As a consequence of the teacher's realization of additional subject matter content, activity 14.18 -- the invention of the oxygen-carbon dioxide cycle through class discussion -- was done prior to engaging in chapter fifteen. This went very poorly with very little student contribution. The discussion was as follows:

Ms. W: "O.K., we've been doing the experiment with the BTB... are your ready to listen now?... with the BTB solution with a snail and with a plant in the BTB solution and a control each time -- to see what color it changes and also we put some in the light and some in the dark. We did not have very dramatic changes in the -- almost no change -- with those in the light and those in the dark, but we put them -- a few people put them by the light -- and we had more of a change. I asked my class (the second class) to put their Thursday's investigation, umm, by the light, and they looked at them Friday and they had a change much like what Marcus and Mike had with theirs. What happened with your Anacharis?"

Mike: "When it was by the light, turned back to blue."

Ms. W: "It turned blue when it was right close to the light. So it's possible that the ones we did the other day and put on the table here did not have as much light as that one had because we do not leave these lights on overnight. The others did not have as much light over there (on the table) so we did see a lot more change than the others and and my class overnight noticed the same kind of results -- that the Anacharis turned blue so, in other words, what is this telling us? (eight second pause) If the plant changes from green to blue in the light -- what is there the presence of?"

Mike: "Takes in carbon dioxide and gives off oxygen."

Ms. W: "All right. Did anyone have their plant turn blue when it was in the dark? (pause) Did it change? Did it remain green in other words? Like you put it in?"

Mike: "Got lighter?"

Ms. W: "Did it give off carbon dioxide then? (long pause, teacher moves back to demonstration table and looks at the Teacher's Guide) Or, excuse me, yeh, right I'm getting myself turned around. Um, it's um, then it gives off, uh, then it gave off carbon dioxide...

or take in carbon dioxide is what I'm trying to say... that's what we're working on." (uneasy, nervous laugh by students)

Mike: "Problem with the fifth graders (the class previous to this one)? Were they bad again?"

Ms. W: "Yes, they were a little restless again -- some of them. O.K., so what changed? You said the one that were in the, uh, dark stayed green. And the Anacharis in the light we had more of the blue here in my class then. So we did have more of a change after we tried the difference. So, are the plants doing the same thing in the light as they do in the dark? (very low voice, almost inaudible) Yes, they are." (from field notes 12-11-78)

This discussion illustrates the teacher's continued confusion with the subject matter content. The confusion at this point resulted in the teacher actually presenting incorrect content. The nature of the teacher's actual instruction was not a lack of orientation toward learning, rather a confusion about what was to be learned.

The next day, prior to engaging in the start of chapter fifteen, the first science class reviewed the previous activities, their results and conclusion. Chapter fifteen is the last chapter in "Part Thre" and is a set of activities designed for the students to "discover" that the oxygen-carbon dioxide cycle applies to terrestrial plants as well as to aquatic plants. The investigation activities, therefore are almost identical to the ones from chapter fourteen. The students place blue BTB solution in an enclosed environment with a terrestrial plant. Some of the set-ups are to be placed in the dark and some in light (activity 15.02).

As the students in the first class were preparing the materials for the investigation, one of the students asked the teacher why the BTB solution they were to use was blue instead of green. No response was given to the student as the teacher was busy directing student materials use. The teacher indicated during post-instructional comments that she heard the student and between classes reread the Teacher's Guide and then realized the reaction of plants relating to the oxygen-carbon dioxide cycle is different depending on whether it is in light or darkness. The discussion in the second class also reviewed the previous activities prior to starting chapter fifteen and included the proposition that plants produce oxygen in the light and carbon dioxide in the dark. The purpose of chapter fifteen's investigation was also made clearer.

The final day of actual instruction for "Part Three" is to observe the results of the previous day's investigation and conclude that terrestrial plants also produce carbon dioxide in the dark (activities 15.04 and 15.05). The teacher realized the previous day's discussion in the first class did not address the different gas production of plants being dependent on whether light is present or not. Therefore, activity 14.18 -- the invention and discussion of the oxygen-carbon dioxide cycle -- was repeated. The discussion was awkward with the teacher having difficulty forming questions and included very little student contribution. The bulk of the discussion involved review of previous investigation results and development of the proposition that plants produce oxygen in the light. The extent of the proposition that plants produce carbon dioxide in the dark was very brief:

> Ms. W: "...did the ones (plants) in the dark give off oxygen? (pause, no student response). No it didn't." (from field notes 12-12-78)

The lesson then continued and started with the observation of results from the previous day's investigation. The potential knowledge addressed by actual instruction was the same as in the literal program but differed in degree of development. The end of the final day involved activities 15.04 and 15.05 with modification of the oxygen-carbon dioxide cycle similar to activity 14.18 in the literal program. This resulted in a modification of activity 15.05 with respect to the nature and emphasis of subject matter content addressed. The same subject matter knowledge was potentially available for student learning but the amount of explicit attention and development was different from the literal program.

Many of the modifications of the literal program related to the potential subject matter content. The modifications were of two forms. The first type of modification was the virtual lack of attention to propositions other than that blue BTB solution changes to yellow in the presence of carbon dioxide during chapters ten through thirteen. The investigations were done and produced results from which additional propositions could have been derived but were usually not explicitly addressed. The second type of modification related to the development of the subject matter content. Actual instruction resulted in very little development of any propositions other than the interaction between blue BTB solution and carbon dioxide. During chapters fourteen and fifteen, when additional propositions were addressed, the relationship to the results of previous investigations was not developed. The result of the modifications was a lack of student understanding of the subject matter content. While this study does not specifically address student learning, the lack of student participation in discussions and difficulty in answering Student Manual questions, predictions, and problems. indicated a low level of student learning of the subject matter content.

Modifications-Related to Instructional Strategy

The analysis of the literal program included a "Strategy" feature. This feature was included since the SCIS program was reportedly designed and developed with the notion of a learning cycle (SCIS Teacher's Guide, 1971). Each of the three stages of the cycle -- exploration, invention, and discovery -- involve different instructional strategies which relate to the task, student and teacher role features. The strategy feature, therefore, has a rich relationship to the nature of actual instruction.

The analysis of actual instruction reveals important modifications of the instructional strategy which were not evident from the analysis of the teacher's intentions. One modification of the literal program approach related to this strategy feature was the teacher's instructions to the students for doing the investigations. The first four chapters are intended to be the exploration stage of the learning cycle for "Part Three". As stated previously, the activities in the exploration stage are characterized by spontaneous student handling and manipulation of materials with minimal guidance imposed by the teacher in the form of instructions or specific questions (see Nature of the SCIS Program, p. 59). A characteristic feature of actual instruction, however, was the amount of explicit and detailed instructions provided by the teacher. This modification --providing explicit instructions -- is interrelated to the modification of another component of the strategy feature.

Many of the investigations to be done in "Part Three", particularly during the exploration stage, are to be student suggested and designed. Actual instruction, however, typically involved the teacher telling the students the investigation they were going to do. The two characteristics together -- teacher identification of the student investigation and teacher provided detailed instructions -- provide an important element to understanding the nature of actual instruction. Together, the two characteristics compose a large portion of the classroom routine.

The actual instruction for chapter twelve illustrates both of the identified modifications from the literal program. The literal program identifies the following procedure for beginning chapter twelve:

TEACHING SUGGESTIONS

Demonstrating the gas generator. To introduce this activity, set up a gas generator as follows:

1. Fill a plastic cup about half full of water and a vial one-quarter full of water.
2. Insert a plastic tube into the hole in the vial cap to a depth of about $\frac{1}{4}$ inch.
3. Drop one seltzer tablet into the vial of water and snap the cap on the vial (the open end of the tube should not touch the water.)

Ask your students what is happening to the tablet. They should be aware that the tablet is bubbling as it dissolves. Now place the other end of the plastic tube into the cup of water. When the children see the gas bubbling through the water in the cup, ask them how they might test whether this gas contains carbon dioxide. They will probably suggest using BTB.

Children's experiments. Have the children pick up the materials they will need and begin the experiment. (SCIS Teacher's Guide, p. 66)

The literal program makes clear that the students are to suggest how to test whether the observed gas bubbles contain carbon dioxide. Very little attention is given to directing the student assembly of the materials. Actual instruction proceeded as follows:

Ms. W: "All right, I'm going to be showing you what we're going to be setting-up so you follow along. (directions to put away social studies, because of water, etc...) All right, I'm going to give you the instructions as to how you're going to do it. Then I expect you to follow... are you ready to listen?... you con't follow very well if you are talking (two students are talking) ... All right, you're going to be given one of these cups, a vial that has a hole in the cap, and a piece of tubing and a couple of other items that you're going to be using."

"What you're going to do, first of all, is put the tubing through this (she demonstrates putting tube through cap hole).

Now it's going to seem like it doesn't fit at first, but just sort of squeeze it through a little and then put it (the tube) down so its pretty close to the line on your vial; it shouldn't go down below that line. The other end will go in here (the cup). This (the cup) is going to be filled half full, about half way. The other (the vial) will be filled about a quarter of the way. This is the way it's going to be set-up. Then you're going to put this (the hose) down into it (the cup) after you do another step. You will be given one Alka-Seltzer tablet (student giggles and statements of 'plop-plop, fizz-fizz') and BTB solution."

"I'm sure you all know what we're going to be testing for... What are we going to be testing for?"

Students: "... the blue in the vial, carbon dioxide... (inaudible)"

Ms. W: "O.K. Where are we going to put this BTB?"

Students: "In the big cup."

Ms. W: "In the big cup. What are we going to test for then?"

Student: "If the....transferred." "... Blue..."

Ms. W: "Uh, there are too many people talking, I can only hear one or listen to one. Yes, Darrell."

Darrell: "Carbon dioxide will come from the vial."

Ms. W: "O.K., to see if there is carbon dioxide in here" Yeh, right, that is what you're going to be testing for. So, while one person is setting this up -- getting the tube in here, getting the cup on -- the other person is going to put twelve drops of this. Think you will remember that? (wants to write 12 drops on the board, but doesn't have any chalk) Twelve drops. And this is really rather quick to do because you uncap this (the BTB bottle) -- Mike, would you listen -- then you are going to squeeze this carefully and count out -- don't

> squeeze it too hard, you're going to get drops out of there, if you squeeze it too hard, it's going to squirt out and you will have a mess on it and possibly stain your clothes -- so, I put two drops in there, but you will count up to twelve. Sometimes it takes a little while because air gets in there (she tries squeezing to get more drops and has some trouble). (Finishes adding the 12 drops). O.K., you can then mix it up (the solution) with the end of the hose. O.K., I will bring around the alka-seltzer tablet when you are ready for it. I will bring the water around to you too. Now, I am going to ask ... (passes out cups to each pair of students and must relocate two students to have pairs). Two's come up and get the vials (student movement and talking) Fours, come up and get the caps and the BTB. Do not open the BTB until I tell you."
> (from field notes 11-27-78-2 thru 11-27-78-6)

Clearly, the actual instruction is a modification of the literal program. The students are told the investigation they are to do and great emphasis is given to the directions for how they are to do the investigation.

The manner of actual instruction of chapter twelve is understandable when reflected against the classroom demands and the previously presented analysis of the teacher. As previously identified, the main objective of the teacher appeared to be the students' successful use of the materials and the successful completion of the investigation. This required the teacher and students to distribute the materials and assemble them together properly. Accomplishing these requirements was in itself quite demanding. No directions are available regarding the assembly of the gas generator in the student's program materials. This is all part of the teacher's task. The directions provided by the teacher included far more information about the assembly than was indicated in the program materials. Information such as the tube being difficult to fit through the hole in the vial lid, how far to insert the tube, and how to squeeze drops of BTB from the bottle was included by the teacher. The comments of the teacher in the post-instructional review reflected her perspective on the need for such detail and emphasis. At the time she also voiced other considerations such as not calling the seltzer tablet Alka Seltzer due to anticipated student reaction:

> "I did it intentionally (avoiding mention of Alka Seltzer). I guess I didn't want to get them involved in what they were going to do. I thought that I wanted them to know what process -- what they had to do in getting the set up -- that they would maybe get the instructions better if they're not distracted by this other stuff -- what we're going to be using -- because that was taking their minds off of maybe listening to the different parts and what they're going to do."
>
> "It seems very simple, but for kids, this is not simple. I think if I had brought in the fact that, okay, you're going to put some water into this vial and then you're going to put the cap on it too, they would have lost a lot of information along the way, because they would be so involved in getting that water in there and sort of forget what they have to do -- Well, what do I (the students) do now? That was my attempt (it) was to get that thing set up so they knew the parts and set it up."
> (Post-instructional review 11-27-78)

This description of the various aspects of providing instructions clearly highlights what a task doing the investigation is for the teacher. The teacher's primary focus of attention on the how and doing type activities becomes more understandable in light of the fundamental demands of having the students actually manipulate the materials. The possibility of engaging the students in the process of suggesting procedures for the investigation and then doing the activity without explicit detailed instructions was considered by the teacher to be beyond the level of the students' abilities. This accounts for the modifications related to instructional strategy.

PART TWO

Part one of the analysis of actual instruction used the analyses of the literal program and of the teacher's intentions as a comparitive perspective. Part two is a more descriptive analysis of actual instruction. An important part of this analysis examines the classroom milieu -- the environment in which the actual instruction occurs. The milieu is important in accounting for many of the findings of the previous analyses. The analysis from "part one" identified the <u>substance</u> or <u>content</u> of actual instruction whereas the milieu provides the <u>context</u> for instruction.

Many factors contribute to the milieu. Some of these factors are conditions over which neither the students nor teacher have any influence and are described below as general milieu. Other aspects of the milieu are established by the teacher and students as the way they will <u>do</u> science. This is described as the way the classroom works for the teacher and students.

The General Milieu

The general milieu consists of the many factors influencing the school in general, the science class in particular. The school is one in an urban community with a public school enrollment of 30,675 students in the mid-north-west part of the United States. It is located at the farthest edge of the city and has a mixed racial and socio-economic student body. Grades Kindergarten thru sixth are included in the school.

The teacher of interest (Ms. W) has a split fifth and sixth grade class. By choice, she cooperates with another teacher in the school with a similar class. Ms. W teaches all the science and social studies while the other teacher teaches all of the mathematics. The establishment of the split class and rotating student procedures were reported to have been done in order that the two teachers supplement each other's weaknesses and provide better instruction by not having to teach all subjects to their students. They also feel the students rotating to classes during the fifth and sixth grades helps prepare them for life in junior high. These two teachers and a professional aide, who works one-half of each day in a study-hall, rotate the students to different classes in different groups through the day.

Science and social studies are taught by Ms. W in the afternoons. From 12:30 - 1:00, she teaches science and social studies to the fifth graders (18 students). From 1:00 - 1:30, the sixth grade students from the other class (14 students) come in for science or social studies and from 1:30 - 2:00 her own sixth graders (16 students) come back for science and social studies instruction. The teacher typically teaches science during these blocks of time on Monday, Tuesday and Wednesday and social studies Thursday and Friday. Subject matter is flexible during these times, however, and some days science is taught for twenty of the thirty minutes and social studies the other ten.

This split class rotation procedure has been done for several years by these two teachers. This year, however, is the first year they have split the sixth grade class into two sections for science and social studies. Last year was the first year Ms. W implemented SCIS as the science program and all the sixth graders were taught at one time for a fifty minute period. Ms. W reported that procedure had been unsuccessful. She attributed many of the problems to the size of the group (about 35 students) which resulted in material shortages and student confusion in doing the investigations. This year with the sixth graders split into two groups she reduced the time period for each group as well as implemented other modifications which will be discussed in the next section.

The above is a description of the general milieu for both the teacher and students. Many features of the environment cannot be changed by the teacher. Others were established by the teacher in response to previous experience. What actually occurs within the classroom reflects many of these features. The following section describes some of the specific characteristics of the science period.

How the Classroom Works

The analysis of the literal program provided information about the specific activities within the program and many of the features of the activities. Many other aspects relating to classroom operation, however, are not specified in the program. Such aspects as how to start the class and engage the students in the lesson are left for the teacher to determine.

The observation of the actual instruction identified activities which were not from the literal program but which were necessary for classroom organization. This aspect of teaching is not a new discovery. Previous studies have focused on these aspects of the classroom process and have identified them as fundamental components (Florio, 1979; Yinger, 1977). Such activities provide the structure and organization for classroom operation. Yinger labeled these aspects of the classroom operation "routines".. He states, "Routines are an efficient and common mode of operation in situations where action and behavior are repetitive" (p. 142). The operation of the observed classroom contained many such activity routines. These routines are an important part of the milieu of the classroom since they influence a great deal of student behavior.

While previous classroom research has identified routines as a fundamental component of classroom operation, the identification of specific routines is a research problem. The routines are established as an integral part of the total classroom procedures and are not consciously considered by the participants as accomplishing a particular aspect of classroom operation identified by classroom research. As with the identification of activity types, routines may be "discovered" through the examination of the patterns of classroom operation.

Eight basic routines were identified within the science period of instruction. In sequential order they were:

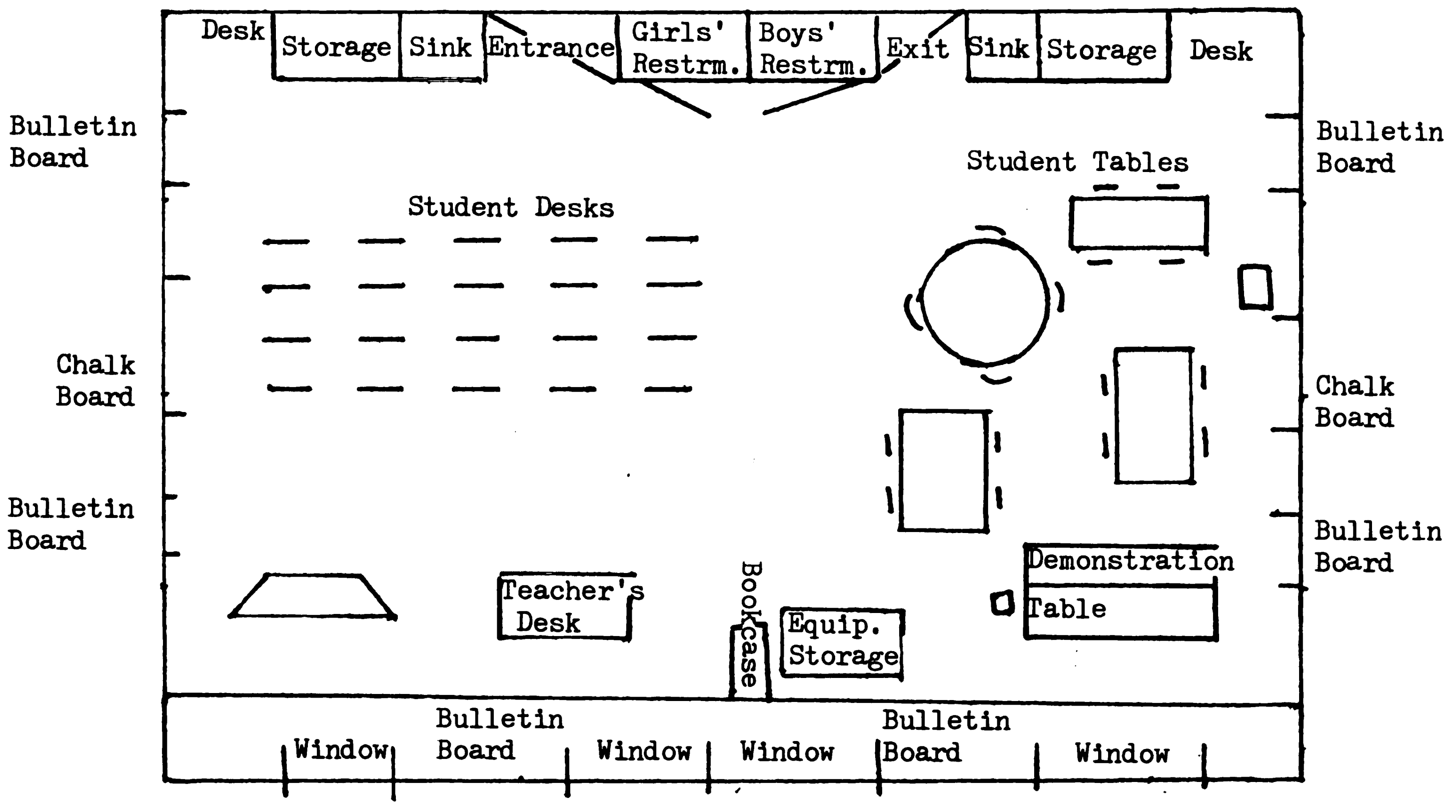
- entering
- introduction
- beginning transition
- instructions
- material distribution
- working
- cleanup
- ending transition

These eight routines structured the student's and teacher's procedures and behaviors throughout the science period. A description of each routine and its function in classroom operation follows.

Routines start as soon as the students enter the classroom. Figure 4-8 shows the physical arrangement of the classroom. The students always enter the room through the east door and go to their assigned desks. During this <u>entering routine</u>, the students

Figure 4-8

Physical Arrangement of the Classroom



may be talking to each other but are supposed to be moving toward their desks. The teacher was always either watching the students in the hall as they changed classes or was behind her desk. A variety of student behaviors were observed during this time. Some students would move immediately to their desks and either read a book or magazine, others would work on an assignment for a class, and others would just sit and talk. Unacceptable student behavior (as inferred from critical intervention by the teacher) was movement in the room to an area other than their assigned seat or being "too loud". The end of this routine was when all the students were sitting and the teacher said "O.K." loud enough for the students to hear. This entering routine appeared to serve the function of orderly student classroom rotation. The events identified as a part of the routine occurred on a regular basis whenever students changed classrooms.

The "O.K." statement signaled the end of the entering routine and also signaled the start of the introduction routine. The statement "okay" by the teacher always resulted in the students stopping all other activity and listening to the teacher, a fundamental behavior and role transition. In the introduction routine the teacher outined what was to be done during the period. During this time she announced if any assignments were to be turned in and whether they would be doing science or social studies. In either case, the teacher briefly stated what the students would actually be doing. After the announcement portion of the introduction routine, assignments were collected or other such administrative tasks were completed. The completion of such tasks completed the introduction routine.

The teacher signaled the start of the next routine -- the <u>beginning transition</u> routine -- by stating: "All right, move to the science tables." This routine consisted of the students moving from their desks to their assigned seats at the science tables. The teacher also moved from behind her desk, where she had given the introduction, to the demonstration table. Students could talk during this transition, but were expected to be moving to their seat. The teacher signaled the end of this routine by standing behind the demonstration table and looking at the students. This appeared to signal another behavioral and role transition. The students were to be attentive as they were during the introduction routine. At times this signal was further clarified by the teacher saying "all right".

The end of the beginning transition routine was immediately followed by the start of the <u>instructions routine</u>. The function of this routine was to provide the students with additional detail about what they were going to be doing and how they were going to do it. This was almost totally teacher centered with the students listening. During this routine, the students would be sitting in groups of four at their tables. Each student at each table had been assigned an identification number of one, two, three, or four at the beginning of the term. As the teacher provided instructions for obtaining and assembling or using materials, she used the identification numbers to assign each student a task. With each task she called a number. This procedure eliminated the need to specifically assign tasks to individual students from each group.

The distribution routine varied depending on the behavior of the students up to this point in the science period. Noise level appeared to be the determining factor as the teacher's behavior related to the student talking. If the students had been quiet during the entering, introduction, beginning transition, and instruction routines, the teacher simply stated they should obtain their materials. Then each student moved through the room according to the task assigned in the instruction routine. If, however, the students had been noisy and the teacher had continually directed them to be quiet, in the distribution routine, the teacher called only one of the identification numbers. Those identified students accomplished their task (such as obtaining vials), while the rest of the students sat at the tables. After one task was completed, she designated another number, then another. While this study did not investigate the establishment of routines, it appeared that such variations relating to structure illustrated the process of how the routines were established in an evolutionary manner. After successful negotiation of acceptable behavior, the distribution routine became less and less structured. If problems occurred, however, the teacher resorted to previous and more structured variations of the routine. Similar forms of variation were also observed in the cleanup and ending transition routines.

Each of the above five routines had to be successfully accomplished before the students began the investigations. The establishment and accomplishment of these routines was a considerable task for the teacher and students. The teacher constantly monitored student behavior to ensure the amount of structure for each routine was appropriate. Likewise, there were many requirements for the students in each of the routines, including a monitoring of the teacher to assess the appropriateness of their own behavior.

Having successfully completed each of the above five routines, the class engaged in the actual investigation. The procedures for this segment of the period were less routinized since the specific behaviors required for actually doing the investigations are much more variable than for entering the classroom or obtaining materials, for example. Some patterns of behavior were observed to occur during this segment however and have been labeled the <u>working routine</u>. As with the other routines, the working routine is very teacher centered. The teacher provides the instructions for what the students are to do and then monitors their progress. The specific content within the routine varies according to the activities designated by the program. The procedures and behavior of the students for doing the activities were, however, established by the working routine.

Once the particular activities for the period were completed in the working routine, a reverse process was initiated. This reverse process starts with the <u>cleanup routine</u>. The cleanup proceeded the same as in the distribution routine. The same procedure of assigning tasks according to student number is used. As in the distribution routine, there were several structural levels of the cleanup routine observed. As before, student behavior -- primarily level of noise -- determined the structural level of the routine implemented by the teacher.

The last routine of the science period, the ending transition, moved the students from the science tables back to their desks. Typically, this transition immediately followed the cleanup. As students finished their assigned task they moved from the science table area back to their desks. Once at their desks, their behavior was very similar to behavior during the entering routine -- reading, working on another assignment, or talking quietly. At this point, the science lesson was completed. No science was ever discussed when they were back at their desks. As with other routines, there were more structured versions of the ending transition routine. If during the working and cleanup routines the teacher indicated there was too much noise, or if it had not gone as directed in previous periods, she would direct them to their cleanup task and then to return to their science tables. The teacher would direct the students to move back to their desks either as a whole group or table-by-table. When this form of the routine was implemented, the students were much quieter and more orderly.

The eight routines described provide the structure for the students and teacher to actually do the activities and investigations. They are an important factor in the establishment of the classroom milieu. They establish a milieu which is quite structured and teacher centered. The routines reflect the acceptable behaviors for the students, required behaviors for the teacher, and a process for accomplishing many of the required classroom functions. The result is the students being able to manipulate the materials as advocated in the literal program. Very few discipline problems occurred since the routines were structured in a fashion to allow the teacher to monitor and adjust procedures in order to control student behavior.

The establishment, implementation, and maintenance of these classroom routines is a large and important task. Without routines it is unlikely the class would be able to successfully even try the manipulations. The described routines not only provided the opportunity for all students to attempt the manipulations, they resulted in their being done according to provided directions.

Analysis of Actual Instruction: Conclusion

The analysis of actual classroom instruction resulted in several conclusions. The most important finding was the teacher's very systematic inclusion, modification, and exclusion of activities from the analyzed literal program approach. The search for an explanation of this exclusion of activities during actual instruction generated the classification of the literal program activities in terms of the what, how, doing and why functions. The analysis of actual instruction using this framework indicated that a high percentage of what and why type activities were excluded.

The postulated orientation of the teacher during actual instruction resulted in a high degree of attention to classroom procedures and management and a low degree of attention to the subject matter content to be learned. The events during actual instruction were heavily oriented toward material distribution and manipulation by the students. They frequently excluded or minimized development of subject matter content discussions. The teacher was very successful in engaging the students in direct manipulation of materials for the doing type activities. The students do manipulate materials. This is one of the major objectives of activity-based science programs such as SCIS. In most cases, this prerequisite step of engaging in an investigation and obtaining information from which subject matter content could be developed was accomplished in a very organized fashion.

The analysis of actual instruction reveals the teacher's concern for student learning of the subject matter content. Also shown was the teacher's lack of understanding of the development and inter-relationship of the potential subject matter content knowledge available in the activities. The overall process of planning, preparing, and engaging in instruction gave less emphasis to the subject matter content than to classroom procedures and management. This high concern for classroom procedures and management was consistent -- there was little modification of the teacher's intentions in actual instruction.

The observation of actual instruction provided an enormous amount of data about many interesting aspects of the teacher-learning process. One aspect important to further understanding the identified teacher's orientation and accounting for the events observed is the pattern of the classroom routines. The identified routines indicated the classroom to be very structured and teacher centered. The teacher is the source for all information related to what the students are to do and how they are to do it. The routines developed facilitated the classroom management requirements for student engagement in the material manipulation activities. The nature of the routines also reflected the requirements of activity-based science instruction (i.e., need for material management and distribution) and are consistent with the described orientation of the teacher.

Other aspects of the teaching-learning process were observed but not developed or analyzed. Such aspects as the different small student group dynamics, the number and nature of classroom transitions, and the nature of individual student engagement in activities are potentially interesting aspects to investigate. This analysis, however, has tried to focus on what appeared to be the most salient features for understanding one teacher's process and procedures for teaching activity-based science instruction.

The original research questions provided some of the orientation for investigation but were, in fact, fashioned from the observation of other teachers' instructional procedures. The literal program influenced the teacher and what actually occurred during instruction to a great extent. For the instructional segment observed, the student investigations advocated in the literal program had a very significant effect on the content of instruction. Significant modifications relating to the component features of activities of the literal program however, were observed during actual instruction. These modifications can be accounted for by the selective process of the teacher in translating the Teacher's Guide. The majority of the analysis of actual instruction was oriented toward understanding the basis for these modifications. The resulting conclusion was that the teacher did not approach planning or actual instruction in a holistic perspective. Rather, the teacher thought in segments of the whole. These segments were approached as independent problems to be semi-solved with different levels of priority. As a result the nature of the first segment addressed and the determined solution effected and influenced the interpretation of later considered segments. The effects of this process were particularly evident with respect to subject matter content addressed. Due to the teacher being first oriented toward the materials, then to how the students were going to be using the materials, and finally then to a more limited extent, to the anticipated results, the teacher misunderstood some of the potential knowledge that could have been addressed in the first four chapters of "Part Three". The teacher addressed each of the four chapters to essentially only one knowledge proposition. While this one proposition is certainly appropriate and fundamental to the investigations, other propositions were also important for the development of more abstract and complex propositions in later chapters. Learning and subject matter content were important and were addressed to some extent by the teacher. Many of the modifications, however, related to the orientation and emphasis the teacher had toward the management of involving the students in doing the investigations.

The analysis of actual instruction, with the perspective provided by the analyses of the literal program and the teacher's intentions, resulted in the conclusion that actual instruction was consistent with the teacher's intentions and that modifications of the literal program were very consistent and systematic. If the analysis of actual instruction only compares instruction to the literal program, the resulting pattern of inclusion, modification, and exclusion of activities indicates some important information. Such a comparison, however, does not provide information about why such patterns occur. The additional information provided by observing and analyzing the dynamics of the teacher and students during instruction helps explain the pattern.

The most fundamental requirement of the SCIS program is the actual participation of the students in investigations. This requires the teacher to first determine what investigation the students are to participate in, what materials are required, how they are to use them, and finally to actually have the distribution, manipulation, and collection of the materials occur for all of the students. This task demands the teacher's direct attention to materials and student behavior. Without adequate attention and success with this, the result is chaos, actual breakdown of the functioning of the classroom.

The demands of the classroom as reflected in the complexity of the management system described help explain this orientation. It is a <u>survival</u> orientation, especially where time was limited. Also the teacher's subject matter background and <u>Teacher's Guide</u>

may contribute to the orientation. The accomplishment of student manipulation of material was a significant and essential achievement for the teacher. In contrast, the additional requirement of determining and then developing all of the potential subject matter content is non-essential to the operational requirements of the classroom. This is consistent with what occurred during instruction and the orientation of the teacher. The comparitive analysis of actual instruction to the literal program and the analysis of classroom operation indicated the above mentioned requirement was not included.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The investigative approach utilized in this research generated a great amount of information concerning activity-based science instruction. In trying to understand the events of actual instruction, the study investigated two important antecedents to actual instruction: the teacher's intentions and the program materials. The results indicated that these three components -- actual instruction, teacher's intentions and the program materials -- interact and are interrelated. These results are consistent with the previously discussed research model proposed by Stake (1974). The specific detail of the investigation, results and analyses of each of the three components have been presented in the previous chapters. The purpose of this chapter is to present a synthesis of the previous analyses and to develop a model of the interaction and interrelation between the three components.

Chapter I began by stating the goal for science education research is to improve student learning. Improved student learning was stated to potentially result from improvement of two components of the teaching learning process: The curriculum and instruction. Further, it was argued change in either component should be preceded by an analysis of the current situation. The development of an explanatory model is consistent with the research strategy and method identified by Pelto and Pelto (1978). They identify three uses for such a model:

> 1. Deductive. Checking features of the model against requirement of established theory.
>
> 2. Inductive. Checking features of the model against new empirical observation.
>
> 3. Internal checking of structural coherence within the model itself. (p. 255)

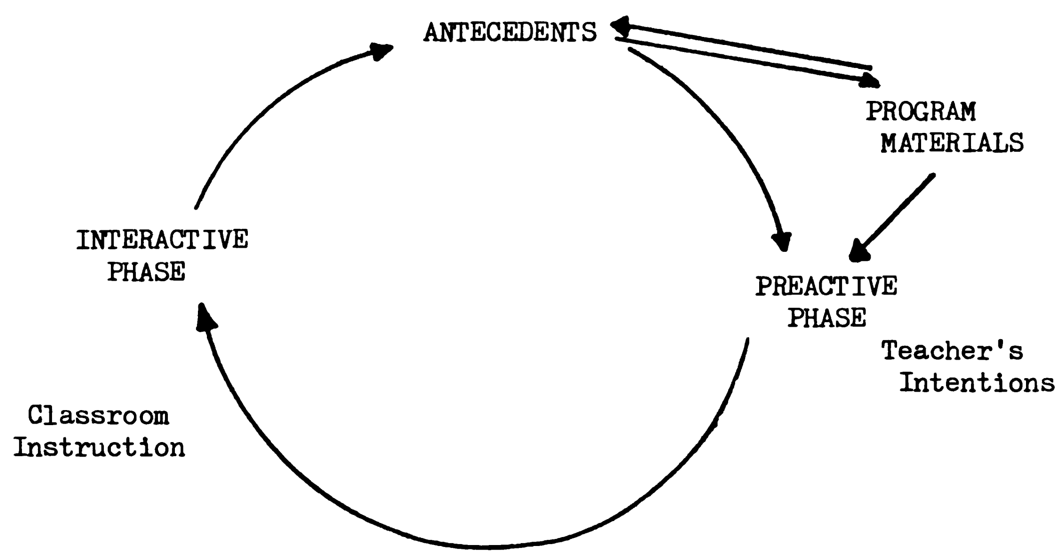
To some extent, the model to be presented has served each of these uses during the process of determining what was occurring during actual instruction. The overall model was not fully developed until after all the data was collected from the study. Various components and relationships, however, were developed as the study was ongoing. Figure 5-1 illustrates the major components of the model and their relationship. The following sections will develop the characteristics of these components based on the previous analyses and related theoretical elaboration.

Introduction to the Model

The general form of the model consists of three major parts: antecedents, preactive phase, and interactive phase. Each of these major parts represents unique aspects of the teaching process. The antecedents are those conditions and components within the environment which are relatively static and unchanging. They are very significant, however, as they provide the fundamental framework and structure for the other major parts. The preactive

Figure 5-1

General Interactive Model of the Teaching Process



phase is where lesson planning occurs. It is where the teacher's orientation for teaching is elaborated. The elaboration is essentially one of determining the specific content for the structure from the antecedent part of the model. The product of the preactive phase is the teacher's intended approach to teaching a specific lesson. The third major part of the model is the interactive phase. This is the actual instruction. Elaboration of each of the major parts, their components and functions will be addressed in later sections.

The terminology used for identifying components in the antecedents and preactive phase parts are taken partially from the study by Yinger (1977). Yinger's study was primarily interested in accounting for the process and product of teacher planning. Many of this study's findings are consistent with those described in Yinger's. In order to highlight the similarities, wherever possible common terminology will be used and identified. Where differences or elaborations were found, it will be noted.

The model is presented in circular form to represent the repetitious cycle of the process. Furthermore, the circular form represents the interactive nature of each major part on the other parts. These interactions between major parts will be addressed in the following sections.

Antecedents

The antecedent parts of the interactive model are shown in Figure 5-2. They are:

1. History and Prior Experience
2. Program Materials
3. Teacher Orientation

Figure 5-2

Antecedent Components

<u>History and Prior Experience</u>

- environment and organization
- student characteristics
- teacher knowledge and experience

<u>Teacher Orientation</u>

- planning dilemma *
- teaching goal *

<u>Program Materials</u>

- curriculum * and resources

* Identifies terms used by Yinger (1978) in a related model.

The first two components, 1) history and prior experience and 2) program materials, are conditions and resources for the teacher. As stated above, the antecedents are relatively static and unchanging. Factors such as the physical location and condition of the classroom; the social, economic and academic background of the students; and the teacher's academic and teaching experience are included in the history and prior experience components. The program materials component consists of the resources provided by the program being taught. In this study, such items as the _Teacher's Guide_, the _Student Manual_, and all of the associated equipment supplied in the _SCIS_ materials kit are part of the program materials components.

In contrast to the relatively static and _external_ nature of the above two components, the third component -- teacher orientation-- is more dynamic and internal. The teacher's orientation reflects the nature of the teacher's conceptual framework for teaching.

Two aspects reflecting the nature of the teacher's orientation are the planning dilemma and teaching goal concept. The planning dilemma represents the general conception the teacher develops for planning for instruction. This in turn is influenced by the teacher's teaching goal concept. The teaching goal concept consists of the features of teaching that are important to the teacher. The nature of these two aspects together reflect the fundamental structure of the teacher's orientation which shape and direct the development of the teacher's intentions.

The most important characteristic of the teacher's orientation is its structure. Evidence from both the teacher's planning and actual instruction indicated the teacher does not perceive or address either process holistically. Particular aspects of the whole were addressed in a sequential fashion. This approach differs from the less differentiated presentation of the program materials. Holistic is used here to represent the manner of presentation of the information as represented by the features of the literal program analysis.

The teacher's orientation influences the way they perceive the program materials. If classroom and material management are important features of the teacher's orientation, the teacher will perceive and translate the program materials in an orientation that is primarily influenced by those features. The teacher's orientation, therefore, may be considered as the structural problem space for the teacher. Determining the specific content of this space occurs during the preactive phase.

The consequences of the teacher's orientation are that during planning the teacher must sort through the information in the _Teacher's Guide_ to find that information required of the particular feature being attended to. For example, the teacher in this study reported first sorting through the _Teacher's Guide_ for information related to the size group the students would be working in during the investigation. Other features related to the investigation are virtually ignored while this feature of interest is attended to by the teacher. During the planning process the teacher reported attending to the following features in sequence:

- student work group size
- relationship of activity to previous instruction
- materials required
- procedure for distribution of materials
- time required for the investigation
- anticipated results of the investigation
- procedures required for cleanup

(from interview, 110678)

Features reported not considered during planning included:

- questions the teacher will ask
- what the students should learn
- what the teacher has to do during the investigation
- relationship of the investigation with future instruction

(from interview, 110678)

Both the features considered and not considered during the planning process are reflective of the teacher's orientation.

The structure of the teacher's orientation will remain constant unless there is some change in the program materials or the features in the history and prior experience component. Examples of such changes might be: teacher attendance of in-service science training; change in school attendance boundries; or the change from the SCIS science program to a different program. Such changes are unlikely and infrequent. Therefore, change in the teacher's orientation is most likely to occur from inputs received from the interactive phase.

The interactive phase is the actual instructuion. If during actual instruction events occur which are not adequately accounted for in the teacher's orientation, a change may occur in the structure in order to address the new requirement. An example of such a change occurred in the reported study. During actual instruction, the teacher had to explain some of the results from an investigation. The teacher's original orientation provided a minimum of attention to the subject matter content being addressed by the investigations. Therefore, the teacher could not adequately provide the required explanation. This resulted in a modification of the teacher's orientation to include more attention to the subject matter content.

Inputs from the interactive phase to the teacher's orientation occur everytime actual instruction occurs. While this may appear to make the teacher's orientation very dynamic and ever changing, this was not the case. The analysis indicates the teacher's orientation addresses the major functioning requirements of the classroom. The results are classroom routines that correspond in nature to the structure of the orientation. For example, in this case the routines and the actual instruction on the whole, provided very limited attention to the development of subject matter content. As stated previously, what was evident was a great emphasis and effort on doing the investigations and accomplishing the material manipulations and management requirements.

In summary, the antecedent part of the model contains components which determine to a great extent the milieu for actual instruction. The teacher'r orientation component provides the structure which determines the nature of the teacher's planning in the preactive phase and the nature of actual instruction in the interactive phase. While most of the components of the antecedent part are static, the teacher's orientation is somewhat dynamic since it is influenced by and is a reflection of the events from the interactive phase.

Preactive Phase

The preactive phase of the model includes the events occurring during teacher planning prior to actual instruction. The product of the preactive phase is the teacher's intended approach for teaching. The features within this phase relate to the teacher's planning process. This phase is very dynamic since every time the teacher plans for instruction something has changed. The planning may be for lessons meant to follow activities from previous instruction and planning; or the planning may be for different students or classroom situations.

In the antecedents part of the model, the teacher's orientation was described as providing structure. The function of the preactive phase is to provide specific substance or content for this structure. The preactive phase is the development and elaboration of the teacher's problem space. The teacher's orientation consists of the essential questions with which the planning process is approached, while the actual process specifies the response of potential solutions.

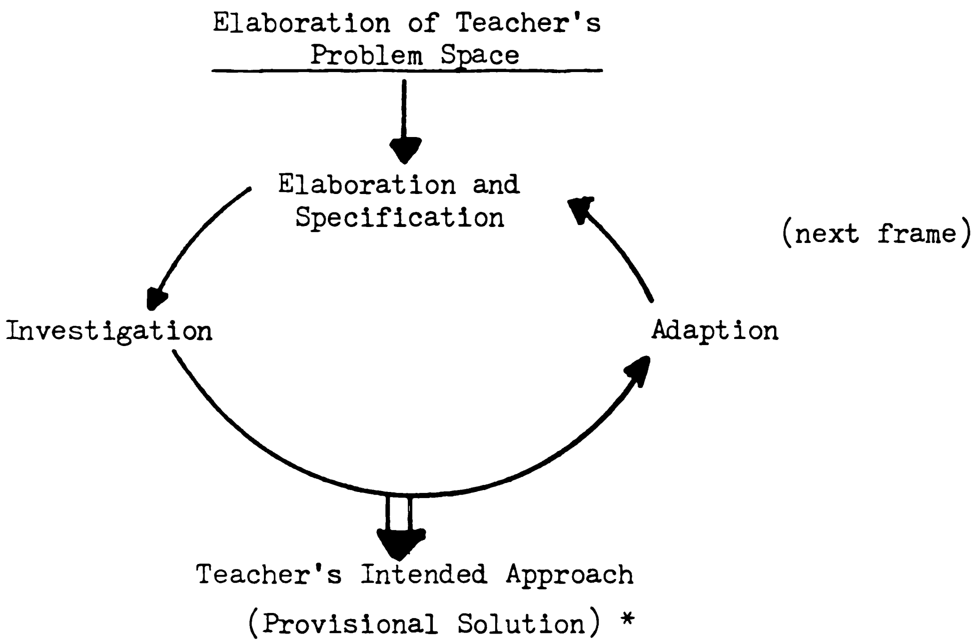
The actual planning process proceeded through a three step process. The first step in the process is elaboration and specification. This step involved identifying the specific problem which requires planning to be solved. For the analyzed case, the problem was identified by examining the Teacher's Guide for the investigation(s) recommended. Once the investigation was identified, the teacher proceeded to attend to features from the teacher's orientation. These features are composed of specific frames. For example, the material management feature consists of frames such as material identification and storage location, material use, and material problems. Each of these frames are addressed sequentially by first determining the requirement for the particular investigation being planned.

The second step, investigation, analyzes the determined specification's workability within the context of the situation. If the specification adequately addresses the frame according to the teacher's orientation, it is accepted as the intended approach for that frame.

After determining the specification of the substance for the first frame, the teacher cycles back to specify the next frame to be considered. The process of determining and establishing the substance of the next frame is addressed. This substance is then investigated with respect to workability. For each frame after the first, a third step is included -- adaptation. Adaptation is the integration of the substance from the second frame with the substance from the first. If the first frame

Figure 5-3

Preactive Phase Components



* Identifies terms used by Yinger (1978) in a related model

identified the material and its storage location, the substance of the second frame -- material use -- must be successfully integrated into an action plan -- such as pre-class preparation required -- before the next frame is considered. The adaptation step of the planning cycle, therefore, is where each succeeding frame solution is integrated into the plan developed from previous frame solutions.

The number of cycles through this process is determined by the teacher's orientation and available time. In order to develop a provisional solution, the frames essential to the teacher's orientation for classroom operation must be addressed and a solution for each determined. If additional planning time is available additional frames within the teacher's orientation may be addressed. The study indicated available time was not typically sufficient to address all the frames within the teacher's orientation. Specifically, the teacher's orientation included a subject matter content to be learned frame, but the available planning time was often less than required to address this frame in addition to the others.

In summary, the preactive phase of the model consists of the events which occur during teacher planning prior to instruction. The features within this phase are addressed sequentially in a cycle. The frames as identified within the teacher's orientation provide the structure to direct the teacher in developing a provisional plan for actual instruction. Each frame is elaborated and specified according to the information provided from the program materials. Once the content for a particular frame is specified, the teacher analyzes its workability within the context of the classroom. Finally, once determined to be an acceptable specification, the content of the frame is integrated with the specified content from previous frames. This cycle is repeated until the content for essential frames is identified and integrated into a potential solution -- a lesson plan. The potential solution addresses and adapts a minimum number of frames from the teacher's orientation. All frames are seldom addressed, due to limited time. The final product of the preactive phase represents the teacher's intentions for what will occur during actual instruction.

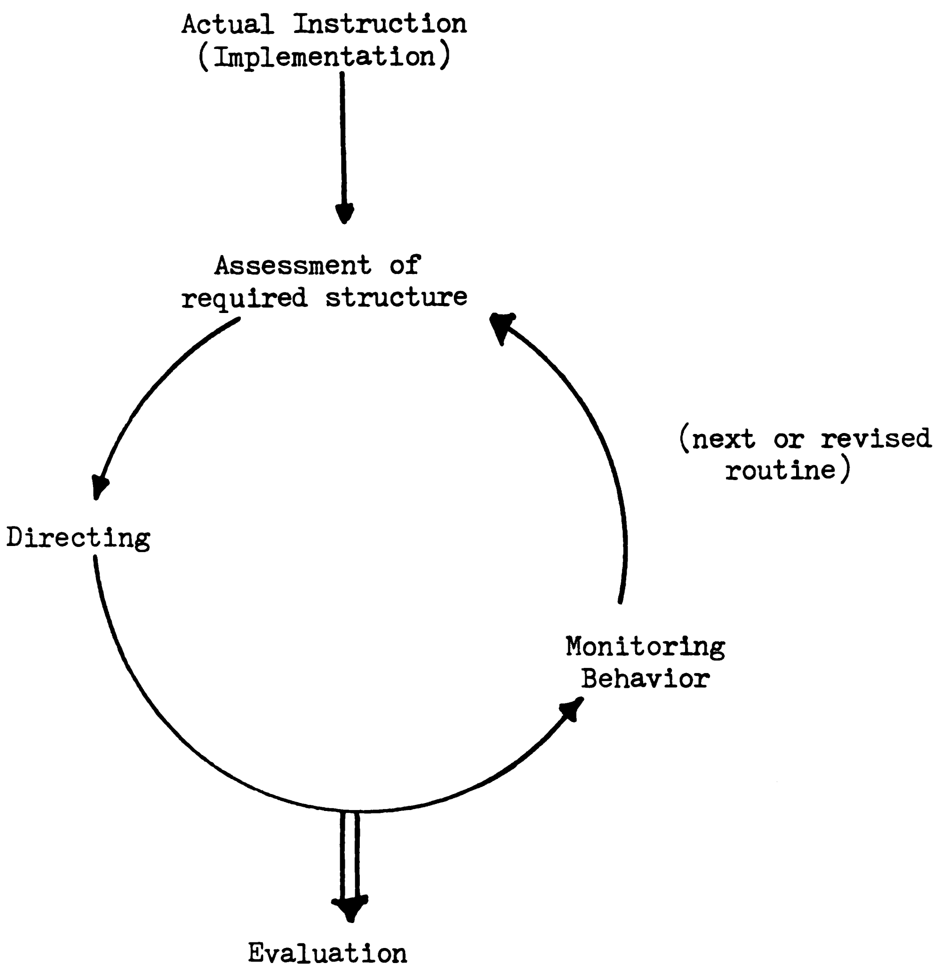
Interactive Phase

The interactive phase of the model consists of the events which occur during actual instruction. The components of the interactive phase part are shown in Figure 5-4. Again, the components identified with this phase relate to the activities of the teacher. As is the preactive phase, the interactive phase is very dynamic since every time instruction occurs some aspect has changed.

The actual implementation of the provisional solution involves the teacher attending to the dynamics and management of the classroom. Here again, a three step process is involved. First, the teacher assesses the degree of structure the students require for successfully accomplishing the tasks of classroom operation. The assessment process begins as the teacher observes the students entering

Figure 5-4

Interactive Phase Components



the classroom. The students entering the classroom begins the set of routines established for classroom operation. Each routine, however, has a range of potential structure. If student behavior is not acceptable to the teacher, she may remind them of a particular quality of acceptable behavior or direct their activity to a more structured level of the routine.

The directing of student behavior is the second step of the implementation process. Directing has two forms. The first form is the teacher informing the students of the particular structure expected for a routine. For example, at the start of the beginning transition, the teacher may direct the students to move to the tables row by row. At other times, the teacher may only direct the students to move to the tables. This still constitutes directing and informing the students of the structure of the routine since previous experience identified acceptable performance.

The second form of directing involves the teacher informing the students of the instructions for doing the investigations. These instructions are the content of the various structures the teacher determined during lesson planning. For example, these directions include indicating what materials are to be distributed and how they are to be assembled and used.

Both forms of directing follow the first step of assessment of required structure. While some of the structured aspects and specific content of actual instruction is addressed and determined during the preactive phase, other structural aspects are determined only after evaluating variables -- such as student behavior -- as they exist in the interactive phase.

The third and last step in the implementation process is the monitoring of student behavior. This step performs two functions. The first function is to provide input for the assessment of the structure required step. The teacher observes the students as they are involved in the various activities of classroom operation. While this aspect of the teacher's behavior may seem obvious, observation from this study and from another, indicates this aspect to have a variety of forms (Sendelbach, 1978). In this study, the teacher maintained a position and behavior which allowed monitoring of all students. Another variety of monitoring observed with another teacher involved that teacher only being able to monitor a small portion of the class during any period of time. The consequences of the two different approaches were dramatic. In this study, the form of monitoring student behavior reinforced the expectations established in the directing step and in the classroom operating routines. The students therefore, were almost always involved with the designated task. The consequence of the form observed in the previous study was reinforcement of expectations only for the group being monitored. Other students tended to wait until they were monitored before engaging in the assigned task. The overall time on task for these students was much lower. Monitoring of student behavior, therefore, may be an obvious aspect of the interactive phase but the nature of its form is significant.

The second function of the monitoring of student behavior step is to determine progress in the planned lesson. This is very important since the class period is defined and restricted. A half-hour after the students arrive the science lesson must be completed since other students arrive. The activity-based nature of the program involving the manipulation of materials for the investigations also dictates attention to progress through the lesson. The last segment of most lessons involves cleanup, collection, and storage of materials. This must be accomplished in order to maintain successful material management. Monitoring also provides input relating to the coordination of the lesson requirements, classroom operation, and available time.

The last component of the interactive phase is evaluation. The evaluation is where the teacher determines if the planned lesson was successfully implemented and whether actual instruction successfully addressed the features from the teacher's orientation. The first notion of evaluation -- whether the planned lesson was successfully implemented -- relates directly to the classroom management and routines aspects of actual instruction. If this aspect of instruction is evaluated as being successful, no change in classroom routines or management is investigated. If, however, the teacher determines the actual instruction to have problems associated with this aspect, changes may be attempted. Such attempts may be re-establishing acceptable student behavior or establishing a different level of a routine structure as the norm.

The second notion of evaluation relates to whether the significant features from the teacher's orientation were successfully addressed and whether they successfully addressed the requirements of instruction. This part of the evaluation completes the connection between the components of the cycle. It shows the direct relationship between the evaluation part of the interactive phase and the teacher's orientation. If nothing occurs during instruction that the teacher has not prepared for during either the preactive phase or in the development of routines, there is no reason for change of the teacher's orientation. If, however, some aspect of instruction does occur with the teacher unprepared, a change in the teacher's orientation is likely to occur. In this study this was seen to occur when the teacher was unprepared to explain the results from an investigation. The subject matter content addressed feature was not a high priority item of the teacher's orientation. The evaluation of actual instruction, however, resulted in increasing the significance of that feature in the teacher's orientation. Subsequent planning and instruction reflected this change.

In summary, the interactive phase of the teaching process model consists of the events which occur during actual instruction. Within the phase is a three part implementation cycle and an evaluation component. The three parts of the implementation cycle are:

- assessment of structure required
- directing, and
- monitoring behavior.

These parts reflect the primary activities of the teacher. By means of these activities the teacher controls both the structure of the events and the coordination of timing of actual instruction. The control of structure is primarily accomplished by establishing the form of the classroom routines to be used. Timing is controlled by the teacher determining and directing when the routines are to occur.

The other component of the interactive phase is evaluation. Evaluation is of two sorts. The first form of evaluation assesses the success of implementing the provisional solution. The second form assesses whether the significant features of actual instruction are accounted for at an appropriately prioritized level in the teacher's orientation.

The interactive phase of instruction, according to the model, is not a final end product. Instead, the events during actual instruction influence later instruction by becoming part of the teacher's history and prior experience and potentially effecting the teacher's orientation.

Discussion and Conclusion

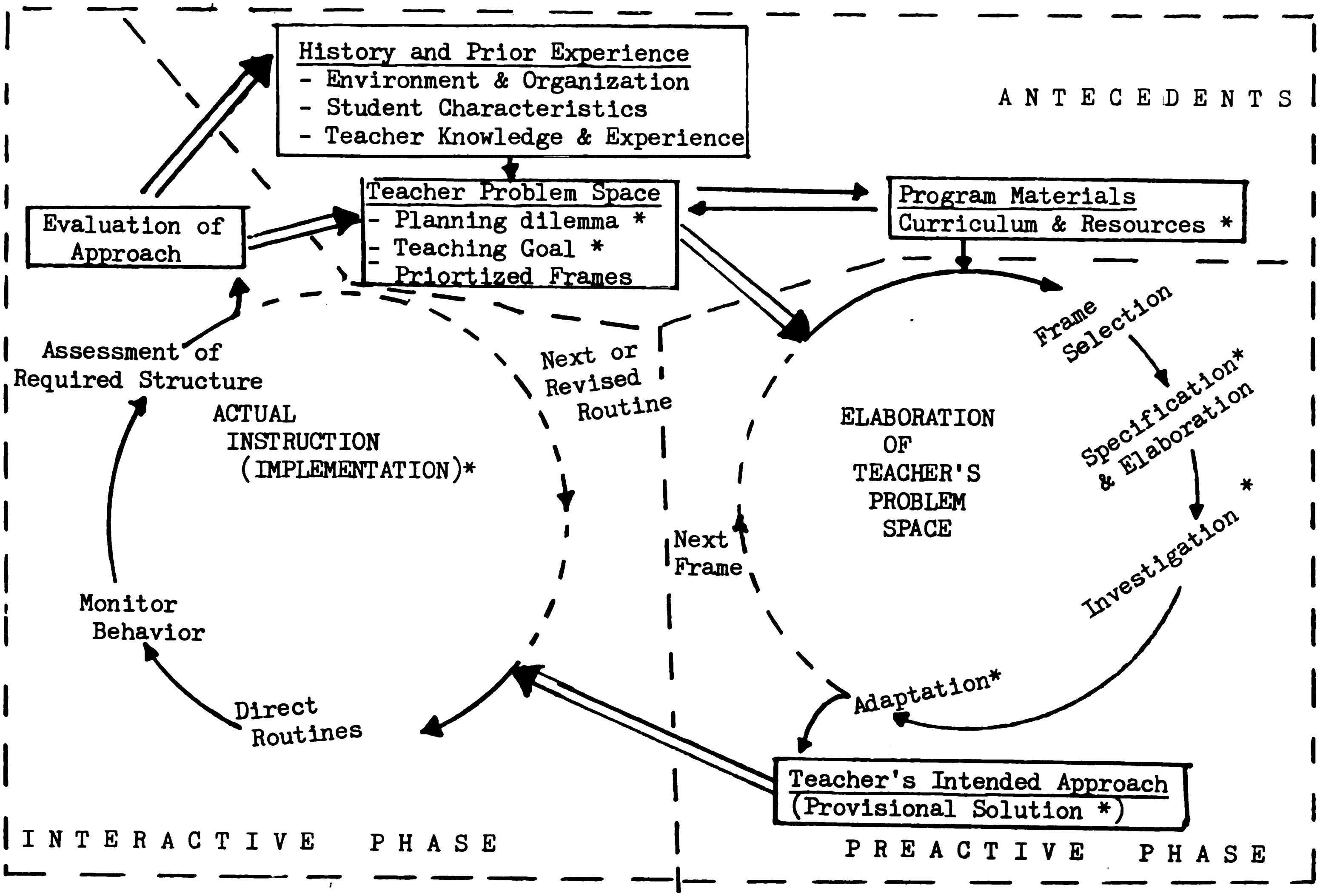
The model of the teaching process presented in the previous section attempts to identify and explain the dynamics between the program materials, the teacher's intentions, and actual classroom instruction. The observations and findings from the study of a teacher planning and teaching part from the SCIS sixth grade Ecosystems unit provided the referent events. Three fundamental patterns provide the framework for the model. Figure 5-5 shows all three major parts of the model with their elaboration and interrelations. The form of the model is circular to represent the repetitious nature of the processes. Within the large circular framework of the total model are two sub-cycles. One sub-cycle occurs in the preactive phase and the other in the interactive phase. Both indicate the teacher's approach to planning and teaching consists of addressing particular aspects of the whole in some cyclic fashion.

The antecedents part of the model provides the structure from which the teacher addresses the planning process in the preactive phase. The teacher's orientation is the component of the antecedent part which provides the structure. This influences the manner in which the teacher perceives and addresses the program materials.

The next part of the teaching process involves teacher lesson planning. This occurs in the preactive phase and involves a three step cycle. The notion of the lesson's content being addressed in a sequential nature according to the frames from the teacher's orientation, is reflected in the three step cycle.
The sequence of frames addressed appears to be directly related to the significance of the frame to classroom and material management. Those frames determined to be essential to classroom operation are

Figure 5-5

An Elaboration of the General Interactive Model of the Teaching Process



attended to and developed first in the planning process. If there is additional available time, the teacher will continue to address frames from the orientation until no time is left. The product of the preactive phase is the teacher's intended approach for actual instruction. The intended approach identifies the content for the structure with which the teacher approaches actual instruction.

The last part of the process involves the actual instruction. This occurs in the interactive phase and also involves a three step cycle. With the structure and content already defined, actual instruction involves the control of the implementation. during this process the teacher assesses the degree of structure required for classroom operating routines, directs student activity, and monitors their behavior. This cycle is repeated throughout the interactive phase. The teacher must be certain to match the classroom operating routine structure to on-going behavior and lesson progress. Finally, the teacher evaluates actual instruction. This evaluation is of both the classroom operating routines and of the teacher's orientation structure. The results of the evaluation may reinforce that the teaching process is successful; that a new or revised operating routine is required; or that the orientation structure requires modification.

The model attempts to account for the major influencing factors and the processes a teacher employs in response. Included in the model are the program materials and management of the classroom factors and attempts to explain their effect and interaction in the teaching process.

The findings from the study are consistent with findings from other studies. Findings reported by Zahorik (1975), Peterson, Marx, and Clark (1977), and Yinger (1977) from other studies of teacher planning indicate teachers to be primarily concerned with determining what the students were going to do. This concern was indicated in this study by the orientation of the teacher to <u>how</u> and <u>doing</u> type activities. The implication is that even when the teacher is using an existing program (as was not the case in the afore mentioned studies) that identifies activities, as in this study, the major concern still focuses on what the students are to do.

The analysis of actual instruction provided information to account for the above orientation. This analysis determined and analyzed the salient features of actual instruction. These features were related to classroom and material management. As indicated in the model, these features from instruction influence what the teacher will attend to in planning. The findings from the analysis of actual instruction relate to other studies of instruction. Doyle (1977), found the most salient features of the classroom to be multidimensionality, simultaneity, and unpredictability. The teacher is shown to cope with these features by implementation of classroom routines. During instruction the teacher assesses the degree of structure required according to those features and their effect and directs student behavior. The ability to establish routines and determine the appropriate level of structure was shown to be fundamental. Since a fundamental objective of activity based instruction is for learning to be addressed from the investigations, the teacher must address the associated classroom and material management demands. This finding relates to other research findings and theoretical propositions.

Kounin and others (Rosenshine, Ryans, Yinger) have suggested that teacher managerial skills are important aspects of classroom operation. With-it-ness, business-likeness/atmosphere, and clarity can all be related to the notion of the teacher's orientation. The critical features of classroom management must be a part of the teacher's orientation and addressed during the preactive phase. This must be accomplished in order that the opportunity for learning can occur. In the terms of Harnischfeger and Wiley (1977), the teacher must first address and accomplish engaging the students on task.

The findings from this study indicate that while time on task is essential, it is not sufficient. The findings indicate that the teacher must also include a feature which addresses subject matter content to be learned. This feature was of particular significance in activities identified as <u>why</u> type activities from the literal program. If the why feature is not part of the essential framework of the teacher's orientation, actual instruction may successfully involve students in doing investigations without developing the subject matter content from the results. Success is defined by the features in the teacher's orientation. The goals and requirements for the students are established through the directing process of the teacher.

If development of subject matter content is not essential within the teacher's orientation, it is unlikely to be addressed by the students. As the goal for the teacher may be to do the investigation, so then are the defined requirements for the students to do the investigations without necessarily attending to subject matter content. As a result, there may be a major percentage of the students involved on-task for a majority of the time. The substance of the task, however, may not include development or learning of subject matter content.

Summary

The model of the teaching process presented in this chapter identified the nature of major components investigated and their interactions. Three parts were identified: antecedents, preactive phase and interactive phase. Each of these major parts consists of component features.

The fundamental characteristic of the antecedent part is the development of the structure from which the teacher approaches both the preactive and interactive phases. This structure was described as the teacher's orientation. The structure will remain constant unless the teacher determines from actual instruction that they did not adequately or appropriately consider essential features of the classroom process.

The nature of the preactive phase is the development of the teacher's plans. During this phase, the content for the frames within the feature structure of the teacher's orientation is determined. This process is accomplished by a three step cycle. The plan is developed feature frame by feature frame instead of in a holistic fashion. This sequential approach to the development of the teacher's plan results in the determination of content from earlier frames effecting the content of later frames.

The last major part of the model involves the implementation of the plan from the preactive phase. This part is the interactive phase, which also consists of a three step cycle. The major components of the cycle are for the teacher to assess the degree of structure required for classroom operation, direct student behavior, and monitor events. The other significant component is evaluation. The evaluation component involves two-way interaction between the antecedents part and the interactive part. The results of the evaluation determine whether modification of the teacher's orientation is necessary.

The overall form of the presented model is circular to represent the cyclic nature of the teaching process. Once established, only changing conditions or unexpected events during the implementation process will potentially change the nature of the teaching process.

CHAPTER VI

DISCUSSION AND IMPLICATIONS

The previous chapters have described and analyzed three major components of activity-based science instruction: 1) the program materials, 2) the teacher's planning process and intentions for instruction, and 3) the actual instruction. The analyses considered both what was described to be the literal program approach and the actual dynamics of the classroom. Finally, a model of the whole teaching process was presented which attempted to account for and explain what actually occurred.

The purpose of this chapter is to discuss the findings and results of this study in the perspective of implications for future research and application. First, the research methods from the three components will be discussed focusing on the usefulness of their individual and combined perspectives. Problems and suggestions for future use in research will also be discussed. Second, implications for future research efforts will be addressed. Here attention will be focused primarily on important hypotheses which can be generated from the findings. The last part of the chapter will examine implications for both pre-service and in-service teacher training.

Discussion of Method

The overall design of the study fills a gap within present research. None of the component parts of the study are new in and of themselves. Program materials, teacher's planning, and actual instruction have all been the topics of other research projects. The approach of using all three analyses in one study, however, seems to be unique. Uniqueness, however, is not sufficient. The approach must also provide new insight and understanding to the teaching of activity-based science.

The following sections will discuss the advantages and disadvantages of the methods used in investigating each of the components of the study.

Program Analysis

The analysis of the program materials was used in order to determine what instruction would be like if taught as described by the materials. This analysis was termed the literal program. The unit of analysis was the activity. Activities were defined as including a set of seven features which define fundamental classroom and teaching elements: task, knowledge addressed, strategy, student role and behavior, teacher role and behavior, materials, and management. This analysis provided a very detailed and useful perspective for comparing both the teacher's intended approach and the activities of actual instruction.

The use of the literal program analysis in trying to understand the teacher's intentions and actual instruction resulted in defining of the activity types. Four activity types were described: what, how, doing, and why. The activity type feature was useful and sould be included in future program analyses to identify the function of an activity. The addition of the function feature to the activity analysis framework will provide another explicit reference for identifying modification. The function feature could be used to define the function of an activity as it relates to a group of activities in an investigation.

If the purpose of the program analysis is for comparitive use, as it was in this study, less documentation of evidence sources for feature identification is required. The function of the documenting process in this study was to provide a reference for the level of inference required. If this reference is important, the documentation process is useful. If the researcher is already intimately familiar with a program's materials, the documentation process is also useful since the documentation forces the researcher to stay within the actual program materials and not to include the resources of their own knowledge and prior experience.

In summary, the methods used in examining program materials for the purpose of identifying the literal program activities were useful. Sufficient detail was produced to identify teacher modifications and exclusion. The perspective of the literal program was important for understanding what actually occurred in instruction. Since the program used is considered to be a major influence on the teacher and actual instruction, a means such as the literal program analysis was necessary in order to determine both the extent and nature of this influence.

Questions or issues to be addressed by future analyses of program materials include:

1) How adaptable are the procedures and set of activity features to analyses of other program materials?

2) How reliable is the analysis procedure? Are the activity features and their content interpreted consistently from the same set of materials by other researchers?

These questions are of concern since the framework provided by the literal program analysis is a major comparative cornerstone for analysis of the teacher's intentions and actual instruction.

Teacher's Intentions

The purpose of the analysis of the teacher's intentions for instruction was to determine the teacher's interpretations and modifications of the program materials. A teacher was selected who was recommended to be a good teacher of the program. The teacher professed to attempt to teach the program as it was intended.

The teacher's intentions were investigated by use of the Science Teacher Planning Simulation System. The primary process involved in this system was the video-recording of the teacher during the planning process. Following the planning the teacher viewed the tape to stimulate recall of thoughts during the process. Both the artifacts produced during the planning and the protocals from the stimulated recall were used to develop a profile of the activities and features of the teacher's intentions.

Since the purpose of the study was to determine and analyze what actually occurs, care was taken not to probe the teacher for her intentions in a fashion that might change the plans and considerations. Most probes were used to gain clarification of stated intentions. One consequence of this procedure was an inability to determine whether some aspects not explicitly identified in this planning process were considered by the teacher though not in a manner identifiable from the given procedure. The results from the analysis of actual instruction, however, did indicate that the aspects for which no evidence had been available in the planning process were not addressed during instruction. Future research efforts could explore whether explicit inquiry into unidenfified features results in modification of teacher planning procedures. Intervention studies related to teacher planning will be addressed in a seperate section.

In summary, the Science Teacher Planning Simulation System is an effective method for investigating the intentions of a teacher planning for instruction from an activity-based program. The analysis of the intentions from this method identified the nature of the framework the teacher utilized in the planning and modification of program materials and activities. Without the additional perspective of relating this planning framework to the dynamics of actual instruction, understanding the basis for the framework would be difficult. If the teacher's intentions are judged only agains the framework of the literal program analysis, an unfair assessment of the teacher could result since many of the interactive requirements of classroom operation are not reflected in the literal program.

Actual Instruction

The purpose of the analysis of instruction was to determine what actually occurred during instruction. It was recognized that this goal was too general at the outset. The primary procedure for investigating instruction was observation in the anthropological and ethnographic traditions. Observation resulted in the most salient features of instruction being identified from actual events rather than being ápriorily determined. Per the design of the study, the perspective of both the literal program analysis and the teacher's intentions analysis influenced the perception and selection of what was salient. The use of both perspectives resulted in the analysis of instruction occurring in two steps. The first part of the analysis was comparative in terms of the activities identified in the program analysis and teacher's intentions. A pattern of inclusion, exclusion, and modification resulted from this part of the analysis.

The second part of the analysis describes what occurred from the perspective of classroom operation. This part accounted for the events and how they made sense from the perspective of the teacher. Only with this second part of the analysis was the first useful for future application. The second part provided the context for understanding the first part of the analysis.

The ethnographic procedures used for investigating what was going on during actual instruction proved to be appropriate for the nature of the research questions. The long-term observations involved resulted in the identification of significant aspects of instruction that other research techniques may not have identified or addressed. Furthermore, the continuous observation provided a means for developing and testing hypotheses about instruction. Both the findings and the proposed teaching process model were therefore grounded in the actual events.

A further benefit of the procedures used in the investigation of actual instruction was the resulting relationship between the researcher and the teacher. My actual presence in the classroom and willingness to talk to the teacher about instruction produced a very open and trusting relationship between myself and the teacher. The teacher believed anyone willing to observe that much teaching was in fact trying to understand what was occurring in a contextual and non-threatening manner. The teacher even stated that research based on the actual events and context of the classroom was very necessary to be useful. Most previous research she was familiar with did not appear to have relevance or application within an actual classroom. She supported the effort of trying to understand the problems of program implementation in real context (field notes, 101278). Since one of the goals of this study is to be useful to the practitioner, the contextual references provided by the ethnographic research methods are appropriate.

The relationship developed between the researcher and teacher also involved a negative aspect. Since the objective was to determine what actually occurred during activity-based science instruction, there was a very conscious effort to avoid any form of intervention that might modify instruction as it would occur. As the study progressed and the teacher was observed to be struggling with the subject matter content to be developed, the positive relationship between us made not assisting difficult. Furthermore, when incorrect subject matter content was presented, the issue of professional responsibility became important. Reaffirming that the results of the study were most important at that time resolved this issue. Errors were not pointed out to the teacher until the unit of interest was completed. These types of situations and problems need to be considered when involved in such field work.

Implications for Future Research

The findings from this study open important questions about generalizability and variation. This section will explore two important aspects of the findings in the context of future research efforts. The teacher's orientation and types of teaching will each be discussed below. The third part of this section will discuss potential intervention efforts.

Teacher's Orientation

The teacher's orientation has been shown to be central to the overall teaching process. This orientation effected the interpretation of program materials in the preactive phase and evaluation of instruction in the interactive phase. The findings from this study indicated the teacher's orientation consisted of a structure of significant classroom features. These features were addressed sequentially in a three step process by the teacher in planning. This process determined the specific content for a particular lesson. The resulting determination of a particular feature's content influences the perspective for addressing the later features. Future research should investigate the degree to which this segmental approach to planning is characteristic of teacher planning. Both the nature of the features used in planning and their interaction are important. The orientation observed in this study focused primarily on features of classroom and material management. This orientation was accounted for and shown to make sense given the actual events during instruction. Questions to be addressed in future research are: What is the nature of other teacher orientations and how do they make sense from the perspective of the teacher?; To what extent is the orientation related to the type of instruction?; Is the nature of the orientation different with different program materials?; and Are the essential features to be addressed in the planning process the same if an established program is used as when the program is teacher developed?. Given the central role of the teacher's orientation, the above questions are important in addressing potential actions for improving teaching.

Types of Teaching

The analyses and findings of this study indicate that types of teaching may be systematically identified and related to the teacher's orientation. Activity-based science instruction could be catagorized into four possible types. The first type could be characterized as chaotic. Routines and procedures for classroom and material management are not established. Many interruptions occur between the teacher and students in attempting to establish order. The teacher is almost totally occupied in establishing order. The nature of the teacher's orientation in this case still would be in the formative stage. Significant features could not sufficiently be identified. This could be characteristic of a teaching novice or student teacher.

The second type of teaching may be designated as one where the teacher's orientation consists of significant features related to subject matter content. Instruction would be somewhat different than characterized in the first type, since the teacher would have very clear objectives for student learning. As with the first type, however, the teacher's orientation would not adequately prepare the teacher to address, establish, and maintain classroom and material management procedures. The consequence of such an orientation would be that the students do not engage in, or are unable to do the investigations from which the subject matter content is to be derived. This type of teaching may be characteristic of the subject matter specialist with no teaching background.

The third type of teaching could involve a teacher orientation much like the one described in this study. The orientation is one fundamentally toward the classroom and material management features. Actual instruction involves direct student manipulation of the materials with a very high percentage of investigations being completed by most students. The orientation, however, does not emphasize features related to the subject matter content. The potential subject matter content to be addressed from the investigation is primarily not developed in a direct manner. This type of teaching may be characteristic of a teaching generalist.

A fourth type of teaching could involve a teacher's orientation that considers all significant features of both the classroom and the subject matter. This type of teaching could be characterized as all students successfully accomplishing all investigations and participating in activities which develop the potential subject matter. This type of teaching could be characteristic of the established teacher without planning time limitations.

Future research could investigate the existance of such types of teaching and determine, if in fact, the nature of the teacher's orientation is correlated as described. If different types of teaching are found to be correlated with features of the teacher's orientation, some of the intervention studies identified in the next part of this section could be very meaningful.

Intervention

The findings from the reported study suggest some potential interventions in future research to determine effect. Interventions are suggested for different phases of the teaching process. Specifically related to the program analysis, one form of intervention could be to provide the teacher with the activity analyses framework. Such an intervention may be nothing more than identifying the seven basic features of the activity analysis to the teacher In the planning process, the teacher would be asked to identify the content for each activity feature in the lesson. Another form of this intervention could be to provide the actual activity analysis to the teacher as a supplement or replacement to the Teacher's Guide. Such interventions could help identify whether one teacher problem is the sorting of the original program materials into a classroom framework. Alternatively, the explicit identification of the activity features may effect the orientation structure of the teacher. These interventions potentially could be effective for a teacher involved in the third type of teaching described.

Intervention may also be attempted during the interactive phase. Both the first and second types of teaching could be effected by providing more explicit direction for the procedures and classroom and material management requirements. However, this approach seems very abstract for the nature of the problem. Review of videotaped segments of instruction could provide the teacher with a perspective unattainable during actual teaching. Observation of the classroom dynamics without the demands of responding could provide the teacher the reflective opportunity to consider other approaches. Videotapes providing examples of procedures and classroom routines of the third and fourth types of teaching could also be useful.

A potential intervention for the third type of teaching described could be to provide the teacher with student evaluation materials. The availability of such materials could result in a change in the essential features of the classroom that the teacher attends to. Or, the explicit feedback concerning student learning could modify the teacher's orientation for the evaluation component of the interactive phase.

Each of the above actions are recommended as forms of intervention to be used in future research efforts. While some of the suggested actions could be useful in preservice and inservice training (to be addressed in the following section), further information is needed to understand their effect on the teaching-learning process. Again, the actions should be studied in order that the solutions to one set of problems do not result in trading for a new set of problems.

Implications for Teacher Training

The above implications relate to future research efforts. This section will discuss implications for applied pedagogy. The pedagogic implications relate to both preservice and inservice teacher training.

Preservice Teacher Training

One orientation to preservice training for teacher candidates in science is to concentrate on the various forms of activity-based programs. To a great extent this involves determining the nature of structure inquiry involved in implementing activities. The primary emphasis in such preservice methods courses is that science should not be taught only by the reading of a book, but should be experienced by doing investigations. This viewpoint is stated in a widely used curriculum textbook:

> In years past, the focus of education was on facts, but it has become evident that knowledge of vast resevoirs of facts, while beneficial, is not necessary. Particularly is this true since today's "facts" in science may be tomorrow's falsehoods, and since past and current knowledge may now be stored in an electronic brain. The trend today is to utilize man's capabilities as a thinker and to encourage him to seek the answers to the "why" behind the "what". In other words, science should be taught as an intellectual pursuit. The student thus learns how to think as a scientist. Through carry-over to other subject areas, this trend could affect the total curriculum of each pupil.
>
> The most important aspect of this trend, however, is that through the search for explanation of phenomena, learning becomes a process of self-directed self-discovery. Educating the learner to seek explanation of this environment enhances and perpetuates continuous learning. (Hounshell and West, page 245)

The emphasis is for the teacher to involve the students in investigations. The actual learning is presented to be student directed and self-discovered.

The findings from this study indicate that preservice teacher training relating to activity based science instruction should emphasize two additional aspects. The first aspect relates to the subject matter content. The current emphasis relating to merely involving students in activities is not enough. Training should be certain to stress the purpose of doing activities involves both process skills (the doing of activities) and the development of propositional knowledge (the why of doing activities). Interpretation of program materials using the activity analysis framework may be useful in understanding such different aspects of the program.

The second aspect for preservice teacher training consideration relates to classroom routines. The high degree of classroom complexity for activity based instruction requires the development of mutually understood procedures for the teacher and students. Explicit consideration of such procedures and alternatives along with their associated consequences and implications should be included as part of preservice teacher training. Thinking of routines instead of individual behaviors may assist the new teacher in reducing classroom complexity.

Inservice Teacher Training

The final area of discussion relating to implications from the reported study addresses inservice teacher training. The findings indicated the most critical needs for the teacher were classroom and material management routines. For the teacher observed, these routines were determined and established through trial and error. A great amount of teacher effort and time was devoted to this final achievement. Inservice training should provide potential processes and procedures along with the various steps for implementation. The identification of the evolutionary implementation process is important as it provides the various structural forms for the procedures and routines.

Inservice training should also address the development of the subject matter content for the teacher. One of the findings from the study was that the teacher did not understand the subject matter content involved in the program. The teacher ultimately discovered subject matter content to be other than what she had believed. By this time, incorrect propositions had already been presented and determining the correct propositions was very difficult and time consuming for the teacher. Inservice training could reduce or eliminate this problem by identifying the subject matter content and propositional knowledge to be addressed. Such training would appear to be most effective if grounded directly within the program being taught.

Summary

The purpose of this chapter was to discuss some of the findings from the presented study with respect to implications for future research and applications. The research design and procedures used provided a very rich and meaningful set of data. The advantages, disadvantages, and potential modifications for each of the procedures used was discussed. The findings of the study were discussed in relation to findings from other studies. Implications for future research were presented as they related to the model of the teaching process. Four fundamental types of teaching were proposed for future research. Implications were also presented for both preservice and inservice teacher training.

APPENDICES

APPENDIX A

LITERAL PROGRAM ACTIVITY ANALYSIS

The information available from both the literal program and teacher intentions was a variety of data in relatively unstructured forms. The method developed for organizing and reducing this information to more useable form is an important feature of the study.

The procedure for representing the literal program approach and a teacher's intentions is to build a detailed model using the instructional activity as the unit of analysis. The models are built as a series of instructional activities encorporating information from all data sources. A scheme of activity features guide the identification of relevant information.

An instructional activity can be thought of as a unit in the flow of the classroom instruction. It has a beginning or period of initiation, a continuity, and, unless terminated prematurely, an ending with sense of closure. A distinction should be made between an activity and a class period or lesson which is arbitrarily defined as a certain interval of time. Thus, a science class may involve more than one activity. Likewise, an activity might not be completed in one class period.

The notion of an instructional activity presented above requires an operational definition in order to reliably distinguish between the larger activity and two or more closely related activities. This definition is made in terms of changes in activity features as described in the following section. Some sense of goals and strategic use of activities both by the program developers and the teacher is expected, although not necessarily specific or conscious. Thus, additional aspects of the problem of such a description is the identification of the program's teacher's goals (if any) and the intended strategic functions of activities (if any). The process will be open as to the nature of these aspects, as well as to the possibility that a teacher might not use them at all. The sequence employed in identifying and describing activity features using this system is:

1. the task.
2. the materials.
3. the objectives addressed.
4. the student's role and anticipated behavior.
5. the teacher's general role and planned behavior.
6. the strategy.
7. the activity strategy.

The procedure for analysis using this scheme is summarized below. The results of each step were recorded as illustrated in the sample activity analyses from Chapter 10.

Identify the task: The boundaries of an activity are identified by determining where the next change in task or change of role for the student or teacher occurred. The procedure for identifying the task consisted of determining the specific assignment to the student; what it was the student was to identify, select, construct, or predict, etc. Identifying the task was most often straight forward with sufficient information provided requiring no inference.

<u>Identify the materials</u>: With the task identified, the necessary materials were usually self-evident. Materials usually consisted of objects from the SCIS unit supplies such as batteries, clips, wire, etc. Required page(s) from the student manual with illustrations or questions for the student were also identified.

<u>Identify the objectives addressed</u>: Again, with the task identified, the objectives and knowledge addressed were identified. The objectives identified were restricted to subject content objectives related to the major objectives identified in the <u>Teacher's Guide</u> at the beginning of the unit. Other objectives were not considered since no explicit reference to such was found, though some may be inferred. Since the objectives were not stated in the description of each activity, some inference was required. Supporting evidence for identifying objectives/knowledge addressed was documented.

<u>Identify the student's role and anticipated behavior</u>: The student's role was most often not explicitly identified within the activity description and therefore required interpretation and inference. The role was derived from examination of the task. The role information is also interpreted from the philosophical view of science education presented by Karplus and Thier in the previously cited reference. Their view is one of direct student hands-on experience in any inquiry mode. The identification of student anticipated behavior consisted only of specific behaviors stated in the <u>Teacher's Guide</u>. Most often none were identified. On occasion, an identified behavior provided additional information for inference to either the student and/ or teacher roles.

<u>Identify the teacher's general role and planned behavior</u>: After identification of an activity's task, student's role and student's behavior, the teacher's role becomes somewhat defined. This role specification is due to the direct relation between student role and teacher role -- i.e., if the student role is to suggest alternative models for the results in a particular circuit, the teacher's role must be as discussion leader soliciting student hypotheses. The detail and nature of such a role is, once again, expanded and defended by Karplus and Thier in the forementioned reference. Without additional information, the validity of the teacher's role is dependent on the proper identification of the student's role. As with the student's anticipated

behavior, identification of the teacher's planned behavior is restricted to specific behaviors suggested within the Teacher's Guide.

Identify the activity management: The management feature was the area for identification of particular activity information not covered by other components but provided significant characteristics of an activity. This would include such information as classroom organization or activity time duration. Only explicit or low level inference information was included.

Identify the activity strategy: With an activity's other features identified, an overall activity strategy was determined. Three basic strategies were identified as possibilities from the Karplus and Thier reference: exploration, invention, and discovery. Each of these strategies have distinguishing characteristics. The exploration strategy is characterized by undirected investigation of new materials and is most often the introductory stage of teaching sequence. The invention strategy is very teacher-directed. The discovery strategy is characterized by students independently testing and applying new concepts. This strategy is usually the concluding stage of a teaching sequence. The validity of the identified strategy is primarily dependent on the validity of the identified student and teacher roles and behaviors and is therefore the highest inference component in the classification procedure.

LITERAL PROGRAM ACTIVITY ANALYSIS

1. Activity Name: ·10.01 - Introduction

2. Literal Activity Text: [a]You might introduce this activity by explaining that over the next few weeks the class will experiment with gases taken in and given off by organisms. [b] Ask the children if they know of a test to identify the gases. [c] If they have had experience with BTB in previous SCIS units, they might suggest repeating those activities.

3. Other references: ·Previous use of BTB solution in earlier work from SCIS.//"Interactions", "Systems and Subsystems", and "Variables" SCIS units//

4. Task: ·To recall past activities where BTB was used to identify gases.

5. Objectives and Knowledge addressed:

5.1 General Objectives: ·(BTB can identify certain gases)

5.2 Propositional Knowledge: 10.01.1 ·Gases can be identified.

10.01.2 ·Organisms take in and give off gases.

5.3 Procedure Knowledge: 10.01.3 ·A means for identifying a gas is by bubbling through BTB solution. //From previous SCIS units//

6. Strategy: ·(Discovery) The application of previous knowledge of interaction between BTB and Carbon Dioxide in a new setting.

7. Student

7.1 General Role: ·Discussion Participant

7.2 Anticipated Behavior: ·"If they have had experience with BTB in previous SCIS units, the students may suggest repeating those activities."

8. Teacher

8.1 General Role: ·Discussion Leader

8.2 Planned Behavior: ·"Explain that over the next few weeks the class will experiment with gases taken in and given off by organisms."

9. Materials: ·None

10. Management: ·Whole class

Teacher's Orientation

The teacher's orientation has been shown to be central to the overall teaching process. This orientation effected the interpretation of program materials in the preactive phase and evaluation of instruction in the interactive phase. The findings from this study indicated the teacher's orientation consisted of a structure of significant classroom features. These features were addressed sequentially in a three step process by the teacher in planning. This process determined the specific content for a particular lesson. The resulting determination of a particular feature's content influences the perspective for addressing the later features. Future research should investigate the degree to which this segmental approach to planning is characteristic of teacher planning. Both the nature of the features used in planning and their interaction are important. The orientation observed in this study focused primarily on features of classroom and material management. This orientation was accounted for and shown to make sense given the actual events during instruction. Questions to be addressed in future research are: What is the nature of other teacher orientations and how do they make sense from the perspective of the teacher?; To what extent is the orientation related to the type of instruction?; Is the nature of the orientation different with different program materials?; and Are the essential features to be addressed in the planning process the same if an established program is used as when the program is teacher developed?. Given the central role of the teacher's orientation, the above questions are important in addressing potential actions for improving teaching.

Types of Teaching

The analyses and findings of this study indicate that types of teaching may be systematically identified and related to the teacher's orientation. Activity-based science instruction could be catagorized into four possible types. The first type could be characterized as chaotic. Routines and procedures for classroom and material management are not established. Many interruptions occur between the teacher and students in attempting to establish order. The teacher is almost totally occupied in establishing order. The nature of the teacher's orientation in this case still would be in the formative stage. Significant features could not sufficiently be identified. This could be characteristic of a teaching novice or student teacher.

The second type of teaching may be designated as one where the teacher's orientation consists of significant features related to subject matter content. Instruction would be somewhat different than characterized in the first type, since the teacher would have very clear objectives for student learning. As with the first type, however, the teacher's orientation would not adequately prepare the teacher to address, establish, and maintain classroom and material management procedures. The consequence of such an orientation would be that the students do not engage in, or are unable to do the investigations from which the subject matter content is to be derived. This type of teaching may be characteristic of the subject matter specialist with no teaching background.

The third type of teaching could involve a teacher orientation much like the one described in this study. The orientation is one fundamentally toward the classroom and material management features. Actual instruction involves direct student manipulation of the materials with a very high percentage of investigations being completed by most students. The orientation, however, does not emphasize features related to the subject matter content. The potential subject matter content to be addressed from the investigation is primarily not developed in a direct manner. This type of teaching may be characteristic of a teaching generalist.

A fourth type of teaching could involve a teacher's orientation that considers all significant features of both the classroom and the subject matter. This type of teaching could be characterized as all students successfully accomplishing all investigations and participating in activities which develop the potential subject matter. This type of teaching could be characteristic of the established teacher without planning time limitations.

Future research could investigate the existance of such types of teaching and determine, if in fact, the nature of the teacher's orientation is correlated as described. If different types of teaching are found to be correlated with features of the teacher's orientation, some of the intervention studies identified in the next part of this section could be very meaningful.

Intervention

The findings from the reported study suggest some potential interventions in future research to determine effect. Interventions are suggested for different phases of the teaching process. Specifically related to the program analysis, one form of intervention could be to provide the teacher with the activity analyses framework. Such an intervention may be nothing more than identifying the seven basic features of the activity analysis to the teacher In the planning process, the teacher would be asked to identify the content for each activity feature in the lesson. Another form of this intervention could be to provide the actual activity analysis to the teacher as a supplement or replacement to the Teacher's Guide. Such interventions could help identify whether one teacher problem is the sorting of the original program materials into a classroom framework. Alternatively, the explicit identification of the activity features may effect the orientation structure of the teacher. These interventions potentially could be effective for a teacher involved in the third type of teaching described.

Intervention may also be attempted during the interactive phase. Both the first and second types of teaching could be effected by providing more explicit direction for the procedures and classroom and material management requirements. However, this approach seems very abstract for the nature of the problem. Review of videotaped segments of instruction could provide the teacher with a perspective unattainable during actual teaching. Observation of the classroom dynamics without the demands of responding could provide the teacher the reflective opportunity to consider other approaches. Videotapes providing examples of procedures and classroom routines of the third and fourth types of teaching could also be useful.

A potential intervention for the third type of teaching described could be to provide the teacher with student evaluation materials. The availability of such materials could result in a change in the essential features of the classroom that the teacher attends to. Or, the explicit feedback concerning student learning could modify the teacher's orientation for the evaluation component of the interactive phase.

Each of the above actions are recommended as forms of intervention to be used in future research efforts. While some of the suggested actions could be useful in preservice and inservice training (to be addressed in the following section), further information is needed to understand their effect on the teaching-learning process. Again, the actions should be studied in order that the solutions to one set of problems do not result in trading for a new set of problems.

Implications for Teacher Training

The above implications relate to future research efforts. This section will discuss implications for applied pedagogy. The pedagogic implications relate to both preservice and inservice teacher training.

Preservice Teacher Training

One orientation to preservice training for teacher candidates in science is to concentrate on the various forms of activity-based programs. To a great extent this involves determining the nature of structure inquiry involved in implementing activities. The primary emphasis in such preservice methods courses is that science should not be taught only by the reading of a book, but should be experienced by doing investigations. This viewpoint is stated in a widely used curriculum textbook:

> In years past, the focus of education was on facts, but it has become evident that knowledge of vast resevoirs of facts, while beneficial, is not necessary. Particularly is this true since today's "facts" in science may be tomorrow's falsehoods, and since past and current knowledge may now be stored in an electronic brain. The trend today is to utilize man's capabilities as a thinker and to encourage him to seek the answers to the "why" behind the "what". In other words, science should be taught as an intellectual pursuit. The student thus learns how to think as a scientist. Through carry-over to other subject areas, this trend could affect the total curriculum of each pupil.
>
> The most important aspect of this trend, however, is that through the search for explanation of phenomena, learning becomes a process of self-directed self-discovery. Educating the learner to seek explanation of this environment enhances and perpetuates continuous learning. (Hounshell and West, page 245)

The emphasis is for the teacher to involve the students in investigations. The actual learning is presented to be student directed and self-discovered.

The findings from this study indicate that preservice teacher training relating to activity based science instruction should emphasize two additional aspects. The first aspect relates to the subject matter content. The current emphasis relating to merely involving students in activities is not enough. Training should be certain to stress the purpose of doing activities involves both process skills (the doing of activities) and the development of propositional knowledge (the why of doing activities). Interpretation of program materials using the activity analysis framework may be useful in understanding such different aspects of the program.

The second aspect for preservice teacher training consideration relates to classroom routines. The high degree of classroom complexity for activity based instruction requires the development of mutually understood procedures for the teacher and students. Explicit consideration of such procedures and alternatives along with their associated consequences and implications should be included as part of preservice teacher training. Thinking of routines instead of individual behaviors may assist the new teacher in reducing classroom complexity.

Inservice Teacher Training

The final area of discussion relating to implications from the reported study addresses inservice teacher training. The findings indicated the most critical needs for the teacher were classroom and material management routines. For the teacher observed, these routines were determined and established through trial and error. A great amount of teacher effort and time was devoted to this final achievement. Inservice training should provide potential processes and procedures along with the various steps for implementation. The identification of the evolutionary implementation process is important as it provides the various structural forms for the procedures and routines.

Inservice training should also address the development of the subject matter content for the teacher. One of the findings from the study was that the teacher did not understand the subject matter content involved in the program. The teacher ultimately discovered subject matter content to be other than what she had believed. By this time, incorrect propositions had already been presented and determining the correct propositions was very difficult and time consuming for the teacher. Inservice training could reduce or eliminate this problem by identifying the subject matter content and propositional knowledge to be addressed. Such training would appear to be most effective if grounded directly within the program being taught.

Summary

The purpose of this chapter was to discuss some of the findings from the presented study with respect to implications for future research and applications. The research design and procedures used provided a very rich and meaningful set of data. The advantages, disadvantages, and potential modifications for each of the procedures used was discussed. The findings of the study were discussed in relation to findings from other studies. Implications for future research were presented as they related to the model of the teaching process. Four fundamental types of teaching were proposed for future research. Implications were also presented for both preservice and inservice teacher training.

APPENDICES

APPENDIX A

LITERAL PROGRAM ACTIVITY ANALYSIS

The information available from both the literal program and teacher intentions was a variety of data in relatively unstructured forms. The method developed for organizing and reducing this information to more useable form is an important feature of the study.

The procedure for representing the literal program approach and a teacher's intentions is to build a detailed model using the instructional activity as the unit of analysis. The models are built as a series of instructional activities encorporating information from all data sources. A scheme of activity features guide the identification of relevant information.

An instructional activity can be thought of as a unit in the flow of the classroom instruction. It has a beginning or period of initiation, a continuity, and, unless terminated prematurely, an ending with sense of closure. A distinction should be made between an activity and a class period or lesson which is arbitrarily defined as a certain interval of time. Thus, a science class may involve more than one activity. Likewise, an activity might not be completed in one class period.

The notion of an instructional activity presented above requires an operational definition in order to reliably distinguish between the larger activity and two or more closely related activities. This definition is made in terms of changes in activity features as described in the following section. Some sense of goals and strategic use of activities both by the program developers and the teacher is expected, although not necessarily specific or conscious. Thus, additional aspects of the problem of such a description is the identification of the program's teacher's goals (if any) and the intended strategic functions of activities (if any). The process will be open as to the nature of these aspects, as well as to the possibility that a teacher might not use them at all. The sequence employed in identifying and describing activity features using this system is:

1. the task.
2. the materials.
3. the objectives addressed.
4. the student's role and anticipated behavior.
5. the teacher's general role and planned behavior.
6. the strategy.
7. the activity strategy.

The procedure for analysis using this scheme is summarized below. The results of each step were recorded as illustrated in the sample activity analyses from Chapter 10.

Identify the task: The boundaries of an activity are identified by determining where the next change in task or change of role for the student or teacher occurred. The procedure for identifying the task consisted of determining the specific assignment to the student; what it was the student was to identify, select, construct, or predict, etc. Identifying the task was most often straight forward with sufficient information provided requiring no inference.

<u>Identify the materials</u>: With the task identified, the necessary materials were usually self-evident. Materials usually consisted of objects from the SCIS unit supplies such as batteries, clips, wire, etc. Required page(s) from the student manual with illustrations or questions for the student were also identified.

<u>Identify the objectives addressed</u>: Again, with the task identified, the objectives and knowledge addressed were identified. The objectives identified were restricted to subject content objectives related to the major objectives identified in the <u>Teacher's Guide</u> at the beginning of the unit. Other objectives were not considered since no explicit reference to such was found, though some may be inferred. Since the objectives were not stated in the description of each activity, some inference was required. Supporting evidence for identifying objectives/knowledge addressed was documented.

<u>Identify the student's role and anticipated behavior</u>: The student's role was most often not explicitly identified within the activity description and therefore required interpretation and inference. The role was derived from examination of the task. The role information is also interpreted from the philosophical view of science education presented by Karplus and Thier in the previously cited reference. Their view is one of direct student hands-on experience in any inquiry mode. The identification of student anticipated behavior consisted only of specific behaviors stated in the <u>Teacher's Guide</u>. Most often none were identified. On occasion, an identified behavior provided additional information for inference to either the student and/ or teacher roles.

<u>Identify the teacher's general role and planned behavior</u>: After identification of an activity's task, student's role and student's behavior, the teacher's role becomes somewhat defined. This role specification is due to the direct relation between student role and teacher role -- i.e., if the student role is to suggest alternative models for the results in a particular circuit, the teacher's role must be as discussion leader soliciting student hypotheses. The detail and nature of such a role is, once again, expanded and defended by Karplus and Thier in the forementioned reference. Without additional information, the validity of the teacher's role is dependent on the proper identification of the student's role. As with the student's anticipated

behavior, identification of the teacher's planned behavior is restricted to specific behaviors suggested within the Teacher's Guide.

Identify the activity management: The management feature was the area for identification of particular activity information not covered by other components but provided significant characteristics of an activity. This would include such information as classroom organization or activity time duration. Only explicit or low level inference information was included.

Identify the activity strategy: With an activity's other features identified, an overall activity strategy was determined. Three basic strategies were identified as possibilities from the Karplus and Thier reference: exploration, invention, and discovery. Each of these strategies have distinguishing characteristics. The exploration strategy is characterized by undirected investigation of new materials and is most often the introductory stage of teaching sequence. The invention strategy is very teacher-directed. The discovery strategy is characterized by students independently testing and applying new concepts. This strategy is usually the concluding stage of a teaching sequence. The validity of the identified strategy is primarily dependent on the validity of the identified student and teacher roles and behaviors and is therefore the highest inference component in the classification procedure.

LITERAL PROGRAM ACTIVITY ANALYSIS

1. Activity Name: ·10.01 - Introduction

2. Literal Activity Text: [a]You might introduce this activity by explaining that over the next few weeks the class will experiment with gases taken in and given off by organisms. [b] Ask the children if they know of a test to identify the gases. [c] If they have had experience with BTB in previous SCIS units, they might suggest repeating those activities.

3. Other references: ·Previous use of BTB solution in earlier work from SCIS.//"Interactions", "Systems and Subsystems", and "Variables" SCIS units//

4. Task: ·To recall past activities where BTB was used to identify gases.

5. Objectives and Knowledge addressed:

   5.1 General Objectives: ·(BTB can identify certain gases)

   5.2 Propositional Knowledge: 10.01.1 ·Gases can be identified.

   10.01.2 ·Organisms take in and give off gases.

   5.3 Procedure Knowledge: 10.01.3 ·A means for identifying a gas is by bubbling through BTB solution. //From previous SCIS units//

6. Strategy: ·(Discovery) The application of previous knowledge of interaction between BTB and Carbon Dioxide in a new setting.

7. Student

   7.1 General Role: ·Discussion Participant

   7.2 Anticipated Behavior: ·"If they have had experience with BTB in previous SCIS units, the students may suggest repeating those activities."

8. Teacher

8.1 General Role: •Discussion Leader

8.2 Planned Behavior: •"Explain that over the next few weeks the class will experiment with gases taken in and given off by organisms."

9. Materials: •None

10. Management: •Whole class

LITERAL PROGRAM ACTIVITY ANALYSIS

1. Activity Name: '10.02 - Testing BTB Change From Student's Breath

2. Literal Activity Text: 'Explain that each child should fill a cup half full of water and add about twelve drops of BTB to it (or obtain one-half cup of the solution you prepared). Because the angle at which the bottle is held affects the size of the drops, the blueness of the children's solutions may vary. Rather than trying to perfect the children's technique, let this difference be a variable that the children identify later. Tell the children to exhale through straws so their breath bubbles slowly and gently through the BTB solution. Ask them to look for evidence of a change, but do not tell them what to expect.

3. Other Reference: 'None

4. Task: 'To understand activity instructions given by the teacher.

5. Objectives and Knowledge addressed:

   5.1 General Objectives: 'To understand procedures for bubbling breath through BTB solution and observing and identifying change in BTB solution.

   5.2 Propositional Knowledge:

   10.02.1 'Matter can change in some observable way. //From text//

   10.02.2 'Observation of change is experimental data and evidence for a change having occurred. //From text//

6. Strategy: 'Exploration of change to be observed from activity 10.03 (Teacher is not to tell students what to expect).

7. Student

   7.1 General Role: 'Listen to instructions

   7.2 Anticipated Behavior: 'None specified

8. Teacher

8.1 General Role: ·Provide Instructions

8.2 Planned Behavior:

·"Explain each student should fill a cup half full of water and add twelve drops of BTB."

·"Tell students to exhale through straws so their breath bubbles slowly and gently through the BTB solution."

·"Ask them to look for evidence of a change."

9. Materials: ·None

10. Management: ·Whole class

LITERAL PROGRAM ACTIVITY ANALYSIS

1. Activity Name: ·10.03 - Identify change in BTB solution from interaction with exhaled breath.

2. Literal Activity Text: ·When the children see a color change from blue to green, ask if the solution will continue to change color or what will happen if they continue to blow. Will the solution turn a different color if it is stirred while they are exhaling into it?

3. Other References: ·Activity 10.02

   ·Chapter Objective - Children blow through solutions of BTB and observe that they change from blue...

   ·Part Three Objective - to use data to verify hypotheses...

4. Task: ·Given a cup half full of BTB solution, observe any changes which occur when you exhale bubbles through the solution with a straw and predict additional changes.

5. Objectives and Knowledge addressed:

   5.1 General Objectives: ·(To observe and identify changes - from activity 10.02)

   ·To hypothesize from observations whether change will continue in solution.

   5.2 Propositional knowledge: 10.03.1 ·BTB solution changes from its blue color when breath is bubbled through.//From text and chapter objective//

   10.03.2 ·(Experimental data can be used to help form hypotheses) //From "Part Three" objective//

   5.3 Procedure knowledge: 10.03.3 ·Obtain materials

   10.03.4 ·Observe features of materials (i.e. BTB solution is blue)

10.03.5 ·Exhale bubbles through the solution with a straw

10.03.6 ·Observe materials for change //all from text - 10.03.3 thru 10.03.6//

6. Strategy: ·Exploration or change from bubbling exhaled breath through the BTB solution.

7. Student

   7.1 General Role: ·Engage in procedures given in activity 10.02

   7.2 Anticipated Behavior: ·None specified

8. Teacher

   8.1 General Role: ·Circulate and question

   8.2 Planned Behavior: ·"When students see a color change (in the BTB), ask if the solution will continue to change or what will happen if they continue to blow. Ask if the solution will turn a a different color if it is stirred while they are exhaling into it."

9. Materials: ·Plastic cups

   ·Straws

   ·BTB solution

10. Management: ·Individual

LITERAL PROGRAM ACTIVITY ANALYSIS

1. <u>Activity Name</u>: ·10.04 Observe solution change and label container

2. <u>Literal Activity Text</u>: ·When most of the children's solutions have turned yellow, tell them that they will examine these later to see if any further changes occur. The children should label their cups with their names and store them where they can be easily seen.

3. <u>Other References</u>: ·Activity 10.03

   ·Chapter 10 Objective - children blow through solutions of BTB and observe that they change from blue to green to yellow.

4. <u>Task</u>: ·Bubble exhaled breath through BTB solution (until the solution turns yellow) and observe changes.

5. Objectives and knowledge addressed:

   5.1 <u>General Objectives</u>: ·Follow instructions

   ·Do "store container" procedure

   5.2 <u>Propositional Knowledge</u>: ·10.03.1 //From Text//

   ·10.04.1 BTB solution changes from blue to green to yellow when breath is bubbled through. //Chapter 10 objective//

6. <u>Strategy</u>: ·Exploration of change in BTB solution

7. Student:

   7.1 <u>General Role</u>: ·Observe

   ·Listen to and engage in procedures

   7.2 <u>Anticipated Behavior</u>: ·Label their cups containing BTB solution with their name.

8. Teacher

8.1 General Role: ·Circulate and provide instructions

8.2 Planned Behavior: ·Observe progress of students' BTB solutions to turning yellow

·Tell students they will examine solution at a later time to see if any further change occurs.

9. Materials: ·Container label and marker

10. Management: ·Independent student work

LITERAL PROGRAM ACTIVITY ANALYSIS

1. Activity Name: '10.05 - Description of BTB solution color change and rate of change.

2. Literal Activity Text: 'Have the children describe in more detail the color changes that occurred: what colors the solutions became, and if the change was gradual or abrupt.

3. Other references: 'Data from activities 10.03 and 10.04.

4. Task: 'Given the color change in BTB solution, the student must describe the color change and the rate of color change.

5. Objectives and Knowledge addressed:

   5.1 General Objectives: 'Describe the BTB solution color change and the rate of change.

   5.2 Propositional Knowledge: //Interdependence of activity with 10.03 and 10.04//

   10.03.1

   10.04.1

   10.05.1 'The rate of color change of BTB solution varies.

6. Strategy: 'Exploration of BTB solution color and rate of change.

7. Student:

   7.1 General Role: 'Discussion participant

   7.2 Anticipated Behavior: 'None specified

8. Teacher

   8.1 General Role: 'Discussion leader

   8.2 Planned Behavior: '"Ask students to describe in more detail the color changes that occured."

• "Ask students if the color change was gradual or abrupt."

9. Materials:

10. Management: •(Whole class)

APPENDIX B

STIMULATED RECALL PROCEDURES AND TEACHER PLAN ANALYSIS

The procedures for analyzing the teacher's intended approach consisted of the following sequence:

- video tape recording of the teacher doing actual planning.
- review of the videotape with the teacher utilizing stimulated recall
- analysis of teacher notes, planning videotape, and audiotape from stimulated recall

Following are the instructions and probes used during stimulated recall and examples of both the plan analysis record form and the stimulated recall analysis record.

STIMULATED RECALL INSTRUCTIONS

As you know, we have a video recording of your planning activity. We are now going to review that recording. As you were planning, many thoughts probably passed through your mind. Some of these you may have written down or said out loud. Many, however, were not reflected in any overt communication. As we review the tape, I would like you to try to recall any thoughts or feelings that occurred to you at that particular point during the planning. For example, as you looked at a particular student page you may have recalled what a certain student did during that activity. Or, you may have felt a little twing in your stomach because of a management problem that the activity sometimes causes. Or, you may have had a thought like, "These researchers think they're so hot. I'd like to see _them_ try this with _my_ kids." As we watch the tape I want you to press the intercom button (demonstrate) whenever you recall anything that you throught or felt at that point in the planning. I want to get inside of what was happening as you were planning.

Do you have any questions about this procedure?

STIMULATED RECALL PROBES

. Did you have any specific thoughts or images about...

- What you usually do during this activity?

- What the students usually do during this activity?

- Responses the children have made in this activity?

- Problems the children have had with this activity?

- How you have dealt with this?

- How you would find out if the students have learned what you wanted them to, up to this point?

- Your students reactions to this activity?

. Did you have any specific feelings as you thought about this activity?

. Did you recall anything about the children's feelings as they do this activity?

. Did you recall any feelings you have had while teaching this activity?

. Looking for anything particular there?

. Anything going on there?

PLAN ANALYSIS RECORD FORM

obs. #	tape ref.	source	speaker	Descriptive Notes	Inferences
1	020	V	N	During instructions she is occupied with straightening-up her desk, writing a note to herself, and thumbing through the T.G. She never looks at me.	[1]She already knows what this is about and she is a little nervous and self-conscious about the camera.
2	025			Very brief look at T.G., p.58, the introduction to "Part Three" and then to Ch. 10.	[2]The generalities of the Part are either familiar to her or not considered important.
3	068	V		Visual attention to p. 62 & 63 Ch 10. Ch. number and name are written into plan book and then a list of required materials.	[3]Planning first involves getting ready the materials required for the lesson.
4				Looks ahead to Ch. 11, back to 10 and then decides she needs to look in her schedule book for previous decisions on planning. "I'm going to have to find my keys" (to get schedule book).	[4]Planning involves deciding how long (how many days) the Ch. takes and which days science will be taught.
5	118			Circles time required for Ch. 10 and 11 as suggested in T.G..	[4]Again, shows her concern with time.
6	150			Goes back to p. 58 and states "Trying to find the instructions for mixing the BTB solution is somewhat a problem in this book." Finds something at the bottom of page and makes a note on the page.	[3]Again, the concern is for materials. [6]T.G. is difficult to use.
7	168			Turns to Ch. 11, adds <u>straws</u> to the materials list in her planning book under Ch. 10.	[3]Again, the concern is for materials.
8	179			In Wed. Block of planning book writes #11 and the title of the chapter.	[5]Planning is done for Ch. 10. Material and time concerns have been attended to.
9	192			A list of materials required for Ch. 11 is written below the title.	[3]Time has already been considered and now materials are the concern.

obs. #	tape ref.	source	speaker	Descriptive Notes	Inferences
10	203			There is a brief look at the text of Ch. 11 on p. 65, a look at the following p.66, a check of her lesson plan book and then a check of the Ch. 11 description at the top of p. 64. A note is then added to the lesson plan book.	
11	215			Goes to the science equipment storage area to get out the materials for Ch. 10.	[3]Again the concern is for materials.
12	285			The T.G. serves as the guide for which material will be required. The required quantities are placed in a tray and stored on top of the equipment box.	[6]The T.G. is very important for the teacher even though there are problems.
13	290 305			Returns to her desk. She has finished planning and says: "I did plan for two science lessons next week. But, I have no way of knowing if I can cover them or not because of conferences." She says this is all she normally would plan for. She generally plans for one week. "At least have a general outline of what I'm going to do for the week." "I do have Tues. & Wed. but its possible I might shift Wed. to the following Monday because we might not have a chance to discuss any of No. 10.	Weekly planning primarily consists of determining what activities the students will work on and, therefore, what equipment will be required. When necessary, general equipment is gathered. This level of planning constitutes a general level of planning for teaching. There is evidence of intent to have some discussion of Ch. 10.

STIMULATED RECALL ANALYSIS
(111078) Chapters 10 and 11

Obs. # Tape ref.	Descriptive Notes	Inferences
1	Starts by looking at weekly schedule book. - any thought? - "Mainly thinking of the schedule and what I would have time for because on Monday you will be doing the testing. Conference time Mon. morning so there will be no school then so I will have to work around that."	Thinking in general terms of schedule for school days next week.
2	While seeing herself writing names of materials in plan book: "I think at that point I was writing down some of the things, supplies, that I will need as another reminder because its a little easier to glance in my plan book and look. - 'Do I have these out?" "Need to check these out at the kit at this point because I find it a little more awkward looking here (T.G.). Because here (T.G.) I have to look at what each child needs and what the class needs, but here (P.B.)..."	After determining a rough time schedule, the next concern is for required materials and where and whether they are available and the quantities required.
3	Sees herself look from Ch. 10 to Ch. 11 and back again. -were you looking for anything particular there?- "Yes I was probably looking at the next page that follows - if this is something that continued on or such."	The program is not second nature to Ms. W. She needs to refer to T.G. for even basic information.
4	Any particular thoughts about the lesson from last year? "Some of the thoughts were that this was one that went well last year. Last year was a group of 44 students in one science class which is extremely difficult. But this is one that	The weekly planning process is general, not specific. Daily planning just before class is more detailed, but is only mental not written.

Obs. # Tape ref.	Descriptive Notes	Inferences
	went smoothly. They all had something to do.... Since it went well last year, what I have done is go over the material a couple of times and have it in my mind. What I haven't done to this point is sit down and read the whole page. I will do this Tuesday (day of teaching) before class."	
5	While looking through the pages of Ch. 10 & 11, Ms. W. states she was looking for how long the experiment takes. From the chapter description at the top she points to the T.G. statements of one day for Ch. 10 and two days for Ch. 11.	This point again reflects the dependency of the teacher on the T.G. and how she tries to follow the program.
6	She circles the T.G. reference to the amount of time each chapter will take and says it is another reminder of the time the chapters will take.	Notes are made in both the lesson plan book and the T. G.. Both are used in instruction.
7	She goes back to the Units (Part Three) introductory information and spends some time reading those pages. She states she is looking for instructions for mixing the BTB solution. She is frustrated with page 59 because it is not clearly written with respect to mixing the BTB solution.	This may be evidence for the problem space of the teacher. Of all the info. present in these pages, she is just looking for info. about mixing BTB. Again, a concern for materials.
8	Looking back to Ch. 10 she writes, straws in the lesson plan book. In the review she says she was thinking probably there were no more straws left in the kit and she would have to remember to get some.	Again, concern with materials.
9	While reading Chapter 11, Ms.W. comments she was thinking she didn't remember doing it at all last year.	

obs. # tape ref.	Descriptive Notes	Inferences
10	When asked if she had any thoughts about what she would be doing during the activity, Ms.W. responded: "No, not much because it seemed sort of vague."	
11	The next point is where she says she is going to start getting materials out. She comments this is so she doesn't have to bother getting the materials ready Tuesday (the day of teaching Ch. 10) the next week. She responds she is only focusing on the materials.	
12	To the questions of whether she was having any thoughts about the activity or images of the class while getting out the materials, Ms.W. responded she was thinking about whether the BTB had to sit for a period of time and that she had to have enough cups for every student.	The only focus of attention in getting ready for the activity is on materials.

APPENDIX C

FIELD NOTES and

VIDEOTAPE ANALYSIS EXAMPLES

Field Notes

November 27, 1978

Today, chapter 12 "Seltzer Gas and BTB" is scheduled for both sixth grade classes. The first class enters and is looking at the social studies assignment which is due today. Ms. W. provides them with specific instructions for handing in the assignment. "Have it all organized and in order. First goes the one with the hemispheres, then the other one, and then the paper you wrote. Be sure to staple them together in order." Instructions are repeated three times. "As soon as we are through with this, we are going to go on with science."

T.N. She seems to be rushing them to science. Time is important and she doesn't know how long the activity will take.

Social studies assignment is collected from those students that have it completed and organized. Introduction to

1:07 science: "O.K., Now, we are going to do an investigation, again, trying... making a gas generator.. mmm... I will tell you a little more about it when we sit down at the science tables. So go sit down quietly." This is the lesson introduction which has always occurred while at the desks.

"All right, I will give you a cup of water. I'll just bring it to the tables and you can pour it into both of those for yourselves. To self:"I think we will be a little short, won't we." (realizes they will need more than one cup per table for cups and vials). "Put that in your vial for now." (Ms. W. circulates around to tables to provide water to each). -- One student asks how much water to add to the vial and she tells them she already told them.

T.N. The student may have been confused since the <u>latest</u> instructions were to use the cup of water for the vials. They may have thought they were supposed to use it all. Ms. W. didn't tell her since she feels the students need to learn to listen to instructions more carefully. This seems to be a common problem of miscommunication.

Ms. W. then circulates again to provide them with additional water. The students are assemblying the generators. One student asks if they can put in the BTB. "Yes, put your BTB in there." (to class) Students are very careful to only add twelve drops of BTB.

"All right, I want your attention." (some student commotion as they continue with activity) "Now, if you have gotten your BTB solution in, ah, I notice most of you have your hose in the BTB solution, I want you to take it out of the

BTB now. Because, after you put the alka, ah, the seltzer tablet..(pause). Are you all ready to listen..(pause). You won't know how to do it unless you listen."

T.N. The classic case of trying to get the students to listen to instructions after they have equipment. More effort than normal is required to get the students' attention but not a significant problem. Also interesting to note her attempted avoidance of saying Alka Seltzer. This has been getting off task reaction so she changes to just seltzer tablet.

"After you, you're going to have to open this (the vial) of course, leave your hose in that (the cup) but, open this, drop the seltzer tablet in there, see that it gets started, then put the cover on. Do not have the hose in this cup right away until it gets going. Then when it gets going, after that, you think that it has bubbled enough...inaudible... carbon dioxide. This (the tube) should not be down to the bottom (of the vial) - remember that. As I looked around everyone had it (the generator) done quite well. O.K. there will be one of these (seltzer tablet) for each of you.

(Ms. W. distributes the tablets)

The students add the tablets and are excited about the fiz-
1:20 zling of it. Students start seeing the change in the BTB solution color. Ms. W. circulates around the classroom

and watches the students activities.

T.N. Again, great detail of instructions about how to do the activity, without much attention to subject content.

Most student conversation during this part of the activity is about "Alka Seltzer".

Some students ($\boxed{2}$ x x) start shaking the vial and get additional color changes to orange and dark green. (I think some of the liquid from the vial is being transferred to the cup through the tube) More students try this and get strange color changes.

"O.K., if you've had yours work now, your solution has turned yellow, you know there is the presence of what?"

- carbon dioxide (many students)
- CO_2 (one student)

"O.K., now, you've had a chance to set this up, now each two people are going to have to get this equipment put away. The vials should be rinsed off very thoroughly as well as the hose or tubing so that all that stuff is out of there.

T.N. Very brief discussion or results. Their response that the BTB turned from blue to yellow due to the presence of carbon dioxide is the only point made. There is no mention of <u>evidence</u> for identifying the gas produced by the seltzer tablet as in 12.03. The discussion moves very quickly to the procedures to be used for cleanup: 12.04. Some of the quick transition may be due to her avoiding discussion about the results with the extra "experimenting". This may also account for her stating the results - the solution turning yellow - instead of asking about them.

LITERAL PROGRAM

12:03 Discussion of seltzer gas results

1. teacher asks questions like
   - what kind of gas do the tablets produce?
   - what evidence used to identify the gas?
2. compare results with results of blowing through blue BTB.

12:04 Cleanup

1. solution discarded
2. equipment rinsed and allowed to dry
3. seltzer residue removed

1:24 "I'm going to ask that table 1 begin by pouring out the stuff now and rinsing it out throughly and putting it there to dry. Use both sinks."

- The two boys at 2 comment to her about the color changes they got. Ms. W. ignores them and continues to supervise and direct cleanup.

As the students are finished cleaning up, some water the terrarium and the rest go sit at their desks.

"Uh, if you have those papers in (social studies) you should have handed them in - otherwise continue working on them. Get them in as quickly as possible. We will be going

1:31 on to some other social studies work. O.K., you may go now."

As one student leaves ($\overset{x}{\boxed{4}}$) he comments to Ms. W. that the material on the chalk board is from experiments they had a couple of weeks ago (evaporation and condensation of freon). She tells him she doesn't have anyone who does that board regularly and it was time she erased it. And so she does.

Before the next class enters, Ms. W. comments to me about how quickly the activity seemed to go. She thought it started slowly.

1:32 Second class enters. Some students must have heard from the other class what today's activity involves since they are singing the Alka Seltzer song.

T.N. There could be an effect of some students hearing what the activity is about. The effect could be negative -- hearing some specific about the activity, such as it involves Alka Seltzer, could result in the students not attending to Ms. W. since they think they know what the activity is about. Or, the effect could be positive -- the information could provide the students with a framework for relating the input by Ms. W.. I tend to think the effect is positive, if anything, since the students do seem to attend to Ms. W..

Class starts the same with instructions for finishing and handing in the social studies work. Lots of low level noise and movement while this is being done.

1:36 "All right. Quiet down now. We're going to do a science investigation again working with the BTB solution and I will explain more of it when you get to your science seats. I'm going to ask you to go to your science tables; please do not take your social studies along with you. Go to your science tables now." Students move to tables with relative ease and low level noise. While the students move to the tables, Ms. W. gets the vials from the sink area. Her attention to the materials allows more time than usual for the transition but only results in low level student talking.

"O.K., now I'm going to show you what you're going to do and give you verbal instruction so I suggest you all listen carefully because I'm not going to repeat the instructions again later on -- this will be it. If you don't get them, you're going to be in a little difficulty."

T.N. Two changes from the first class; one is clear instructions not to bring social studies to science tables and, two, emphasis on listening to instructions. Both were problems experienced in the first class. Such slight modifications from the first class to the second could account for her comments that the second class always does better.

Ms. W. explains what materials will be used and how it will be used as in the first class. Also same for making BTB solution and delegation of tasks.

1:41 Distribution of equipment starts. Ms. W. supervises and directs equipment distribution. Ms. W. circulates to distribute water as the students assemble the generators. Several students ask how much water to add to the vial: "Do you want us to add $\frac{1}{4}$ full vial?" She responds she already told them. When another student asks, she responds: "I told you people how much water there had to be in there, why didn't you get it sorted out?" Students continue to work.

1:46 Ms. W. asks if they're ready. She has to tell some that they need water in their vials. She then provides instructions for the next step. She repeats a description of the way their generators should look. There is an emphasis on removing the tube from the beaker until after the seltzer tablet starts to bubble.

Ms. W. circulates around the room to distribute the tablet. As the students add the tablets there is a great deal of excitement and calling outloud of the colors the BTB solution turns. Two girls at table 3 x put the tablet into the beaker instead of the vial. Others in the class notice, comment and laugh. Ms. W. comments that she thought she gave instructions. More class comments about how it looks. Ms. W. "Would you quiet down now everybody -- I think I made it clear to everybody where the seltzer tablet should go because everybody in the other class did it correctly. This class we had a few people who had to check with others because they didn't remember what I said. Right?" Very quiet. "All right, what happened? Raise your hand. Jenny."

-"When it started bubbling, I put the tube in here and it turned a yellowish color. With brownish dots floating around."

Ms.W. "What -- does this tell you anything? Kevin. What information might you get from this judging from what we've been doing so far?"

"Carbon dioxide"

Ms. W.: "Where is carbon dioxide?"

- "from the tablet"

Ms. W.: "How do you tell this?"

Jimmy: "When we blew the carbon dioxide in here it bubbles but when there wasn't any carbon dioxide going into it, it just stayed... stayed blue... "(class noise)

Ms. W.: "Just a minute, I was asking some questions and I wish you'd listen. All right, Jimmy was explaining."

Jimmy: "Well, when we were blowing into it, the carbon dioxide into it, it turned it to a yellowish color. When we weren't, it turned back to the regular blue color. Now that there is carbon dioxide going into it, it turned to a yellowish color. If you took this (the tube) out it would turn back to the blue color."

Ms.W.: "O.K. so we were with this gas generator we were making.. ah,,. or trying another test for carbon dioxide. So BTB solution is a test for carbon dioxide...whether carbon dioxide is present. All right, now you're going to take this apart but I want you to follow and listen carefully to instructions so maybe we can have everyone follow instructions this time."

Instructions for cleanup are the same as first class. Very detailed. After instruction, Amy asks about the liquid traveling through the tube; about its moving. Other students look. Ms. W. does not respond but tells them to start cleaning up.

1:54 Cleanup is quiet but students are trying different things with the materials at their tables.

Ms. W. continues to direct and supervise cleanup but makes no remarks nor responses to student explorations.

As there becomes a greater congregation around the sink with explorations, Ms. W. tells them to hurry up and sit down. As they continue, she gets angry and tells them to "Sit down, now!" The students are quieter and continue to cleanup or sit down.

2:00 Cleanup is complete and everyone is sitting down.

T.N. There is a great deal of emphasis in both classes about what is going to be done and how to do it. The second class has a better discussion. This may be attributed to Ms. W. having gone through it with the first and having more organization for the second. Since she doesn't have to be thinking as much about what still needs to be done (she already knows from the first class) she, perhaps, can think more about the discussion.

Videotape Analysis

December 4, 1978

Chapter 14 is planned to start today. The fifth grade lesson did not go well according to Ms. W. as they would not work quietly enough - she even stopped their lesson early to have them sit at their desks because of the noise. After they left and Ms. W. waited for the first sixth grade class she was still irritated by the misbehavior of the fifth grade class. When she goes to the hall to let the sixth graders in she tells them the fifth graders were too noisy and that when "they come to science they had better quiet down." The students enter the room orderly and quietly.

1:04 Ms. W. informs them "they will be doing another experiment with the science which is called "Inventing the Oxygen-Carbon Dioxide Cycle". She explains they will be working with BTB solution and testing it with Anacharis and snails. She reads this from her plan book as she stands behind her desk.

T.N. This introduction seems to be the orientation to the students (and herself) for the lesson.

She then directs them to go to their science tables. She takes her Teacher's Guide with her from the desk.
The students complain the fifth graders hardly cleaned the tables. (Darrel must have done or said something here I missed) Ms. W. states "I told you, Darrel, I'm not in too good of

humor after that last class!..." "The reason they didn't clean it up is because they were sent back to their seats because they were too noisy." She is now standing at A and places the T.G. open in front of her. She appears to be attending to it. "All right, you're going to be...uh, first of all... you've been (long pause - she is reading from the T.G.) um, talking about oxygen and carbon dioxide, (moves to board and erases word on board) and what has happened (starts to move back to her desk) with these two gases? (gets chalk from desk and returns) What is the purpose of each? What is the purpose of oxygen and what is the purpose of carbon dioxide?"

"We breathe out carbon dioxide and plants breathe in carbon dioxide and breathe out oxygen."

Ms.W.: "Organisms give off carbon dioxide and plants give off oxygen." (she writes both propositions on the board).

T.N. The student referred to people and plants, Ms. W. has changed it to organisms and plants. Ms. W. seems to be carrying the fifth grade vocabulary, "organisms" into this lesson. I also think she believes organisms to be synonymous with animals. She has chosen not to use the Ecosystem chart and is listing propositions in the form she thinks makes most sense.

<u>Literal Program</u>

14.01 - Interaction of oxygen, carbon dioxide, and populations in an ecosystem.
1. display ecosystem chart

2. solicit and list student comments on interactions
3. statements represent a theory of how plants and animals interact with oxygen and CO_2.

Ms. W. asks if there are any other comments and there are none. She adds: "We've been testing for the presence of carbon dioxide. Today we're going to be doing another one." She gets materials and begins to provide information about the materials they will be using (4 vials and BTB solution). She distributes vials, (She still needs to mix the BTB solution) designates students to get books and tells them to open to page 18 for illustration of what they will be doing. She is at A and looking at the T.G.. Has student bring water and has another add BTB.

T.N. Ms. W. seems abnormally unprepared as some of the materials are not prepared. This probably stems from the planning where she related she wouldn't have to get materials out since they are the same ones they've been using. Without doing this, however, these things to do confound classroom operation. They are the things she must be doing and figuring out how to do during the lesson.

She distributes fluted containers and BTB solution. Next, she provides them with instructions: "Two of them blue and two vials that are going to be green (writes this on board)

1:12 Remember when you fill the vials, fill them to the top." As the students do this she realizes she needs straws. Ms. W. comments to me: "I forgot the straws. By next class

I'll be prepared." Students are filling the vials. There is a low level of talking but all on task -- how far to fill vials, who will have blue or green, etc.

"Now, listen to the next step" (Ms. W. is at A, after the statement she attends to the T.G.) "May I have your attention everyone. Listen carefully. The anacharis you have in your terrarium will be put in the green solution and the snail will be put in the blue solution. So the snail is going to be in one, one of the blue solutions, and the other blue is going to be what we call a control -- you're not going to have anything in there.

T.N. Again, very limited attention to an important learning objective; the notion of an experimental control. The emphasis is that the experiment gets set up right.

A similar explanation is given for the green vials with emphasis on filling the vials and capping them. While

1:19 students are doing this Ms. W. looks for and then distributes the colored dots to label the vials. There are no blue ones so she directs them to put yellow dots on the blue ones.

T.N. No attention has been given for why the vials are capped nor why the dots are put on. This is left for the students to infer.

<u>Literal Program</u>

14.03 - Experimenting to determine if animals produce CO_2
1. place snail in vial containing blue BTB

2. prepare control vial
3. label vials with name and color dot

14.04 - Experimenting to determine if plants use CO_2
1. place green BTB in vial with Anacharis
2. prepare control vial
label with name and color dot

Both 14.03 and 14.04 are done in class.

Literal Program

14.05 - Predicting experimental results
1. students do top half of pages 18 & 19
- record starting colors
- predict results
- explain prediction

Activity 14.05 was planned for today but was not done.

T.N. Ms. W. has had to attend to so many material details she has not been able to attend to the T.G. as usual, and therefore, forgets to have the students do this.

1:20 Ms. W. looks for labels for the student vials. Students finish labeling their vials. Ms. W. comes to me and explains, "When I have a class like last hour it always makes the next one hard." We talk briefly about this in a light way. She then returns to A. "All right. Everyone. Will you listen now? Everybody. I'm still waiting for a few tables. Now, you should have your vials closed and filled. Two filled with blue solution; one of the blue ones is going to have a snail and the other one is going to be empty... of any organisms. It will be the control." Same for green vials. Repeat of instructions for dots and labels.

1:26 She explains where to store them, but needs to clear area so changes to little table in front of A. No discussion of why put there, only that they will all be in the same spot. While the students do this and move back to their desks, Ms. W. clears off A.

1:28 All students are seated at the desks. Ms. W. announces she will collect the social studies assignment. Students get papers and she collects them.

1:30 Ms. W. dismisses them. She comments to me that today seems to be a "high" day.

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